ELECTRONICS

Low Noise Charge Sensitive Preamplifier: J. Grünberg and L. Tepper

A low noise charge-sensitive preamplifier was designed and a number of units built. The amplifier is intended primarily for use with solid state detectors, but can also be used with ionization chambers and proportional counters.

The circuit is fully transistorized and includes a field effect transistor at the input stage. It is modelled on the usual scheme of a cascode and boot-strapping emitter follower(1). The specifications are as follows:

Noise: $(10 + 0.2\ C_{in})$ keV, referred to silicon detectors. C_{in} is the external capacitance in pf at the input.

Sensitivity: 400 mV/pico Coulomb
100 mV/pico Coulomb
20 mV/pico Coulomb

Range: 0.1 MeV to 250 MeV (silicon)

Fall time: 100 µsec

The unit is housed in a small box (11 cm long) so that it can be used in relatively inaccessible spots.

Reference :

1. RADEKA, V., "Proc. NAS on Instrument Techniques in Nuclear Pulse Analysis", NSS, No. 40 (1963)

Fast Timing Circuits Using Storage Diodes : J. Grünberg and L. Tepper

A constant-charge pulse-shaper has been used as the basic element in two fast timing circuits using photomultipliers. The shaper is based on storage diodes (snap-off diodes) and delivers an approximately constant amount of charge at the output, almost independent of the input current pulse amplitude. These constant-charge pulses are delivered to a tunnel diode, which in the sub-nanosecond range is a charge sensitive device.

A coincidence circuit and a time-to-amplitude converter were built and operated with a Co^{60} source, two plastic scintillators used with 56 AVP tubes, and a slow coincidence discriminator. With a range of 20 mA to 200 mA, the coincidence slope was 0.4 nsec for half-amplitude, while the time-to-amplitude converter showed a FWHM of 0.8 nsec on a multichannel analyzer.

Fast Counter : B. Remigolski

A Ring Counter based on a combination of tunnel diodes and fast transistors connected in the common base mode(1) was developed. The input requirements of the circuit are a sine wave of 0.5 V amplitude, or else positive pulses less than 5 nsec wide.

The circuit was tested in the frequency range of 100 - 250 Mc. For frequencies lower than 100 Mc a pre-shaper must be added.

Reference :

1. RADEKA, V., Nuclear Instr. and Methods, 22, 153 (1963)

Nucleonic Modules : B. Remigolski

The following modular units were designed as part of a more general modular system of plug-in units:

a) A fast amplifier with a rise time of 3.5 nsec and gain of 100. The amplifier uses two stages of current amplification, each stage having a gain of 10 and a rise time of 2 nsec. The stage itself is based on a current feedback loop of 3 fast transistors.

b) Variable coincidence unit.

The double triple coincidence unit includes:

(i) A fast amplifier (risetime 4 nsec) with a gain of 10.

(ii) A variable tunnel diode discriminator and shaper based on a combination of common base transistor and tunnel diodes.

(iii) A double triple slow coincidence unit with a resolution of 1 μsec. The circuit is capable of working in the mode of delayed coincidence.

<u>Time-to-Amplitude Converter</u> : R. Potascher

A fast time-to-amplitude converter was designed and several units built. The block diagram is given below.

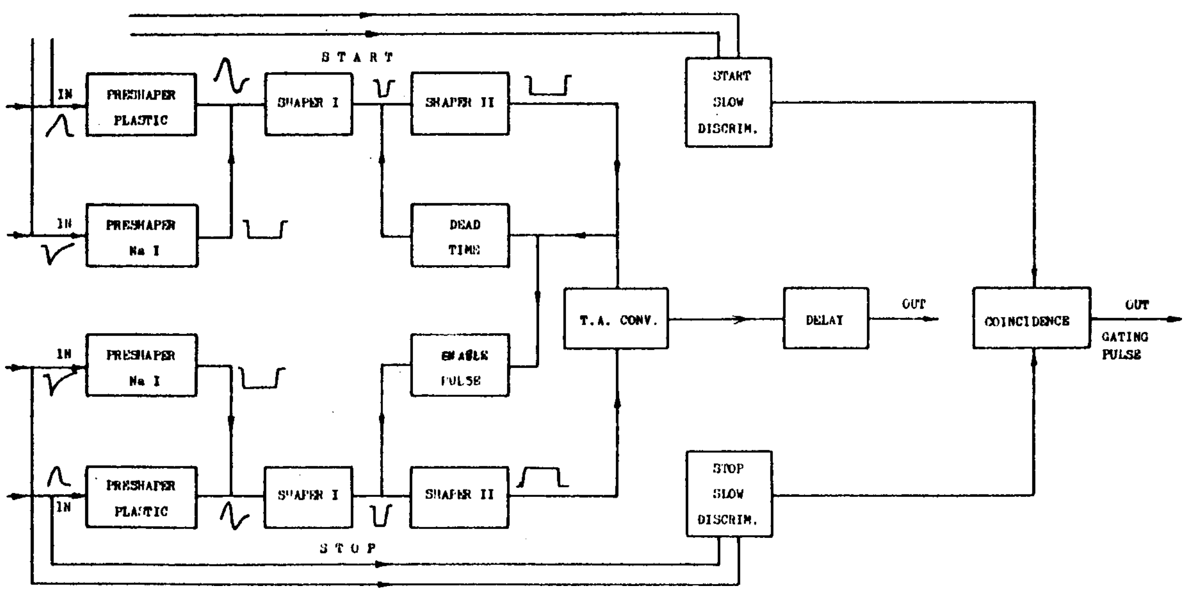

Fig. 55

Block diagram of time-to-amplitude converter

The converter is based on the start-stop principle and the usual method of charging a capacitor from a constant current source. Fast diodes are used as the current switching elements. The preshapers for pulses coming from plastic scintillators use zero crossing, while those for NaI scintillators use limiters. Both types of shaper are current sensitive. The main shapers are fast tunnel diode univibrators.

A slow coincidence circuit with a variable discrimination level is included for the gating pulses. An "enable" pulse is provided to trigger the stop shaper only when a start pulse has preceded the stop pulse. A dead time of 3 μsec is introduced after the start pulse.

The converter has two ranges, 30 nsec and 100 nsec. The time resolution measured as the FWHM on a multichannel analyzer is better than 10 psec using a mercury relay pulser as input source. Using two XP 1020 photomultipliers with plastic scintillators and a Co^{60} source in prompt coincidence, the resolution is 0.6 nsec for the low discrimination level and 0.35 nsec for the high discrimination level in the slow coincidence discriminators. Using a NaI scintillator and a 56 AVP photomultiplier in the start input the best time resolution for Co^{60} prompt coincidence was 0.85 nsec. With two NaI scintillators and 56 AVP photomultipliers the best resolution is 1.1 nsec. Linearity is better than 0.3% in the 100 nsec range and better than 0.5% in the 30 nsec range.

The unit was built as a "nucleonic module" (see previous item), and was developed as a continuation of previously described work[(1)]

Reference:

1. POTASCHER, R., Israel AEC Semi-Annual Report, Jan.-June 1964, IA-984, p.171

Spectrum Stabilizer : A. Senator, L. Tepper

Semiconductor detectors, as is known, show a deteriorated collection efficiency after being subjected to particle bombardment. This deterioration is greater the heavier the particles, and for fission fragments the impairment is particularly rapid.

A spectrum stabilizer[1,2], which is intended to present a steady spectrum at the input of a multichannel analyzer, was developed. It includes a preamplifier, the main amplifier and the detector itself. The stabilization is achieved by means of a variable gain amplifier to which the output of a differential ratemeter is fed back. The instrument was designed mainly for use with solid state detectors, but it is suitable for photomultipliers as well.

The block diagram of the stabilization system is given below. The amplifier gain is changed by means of the field effect transistor working below the pinch-off.

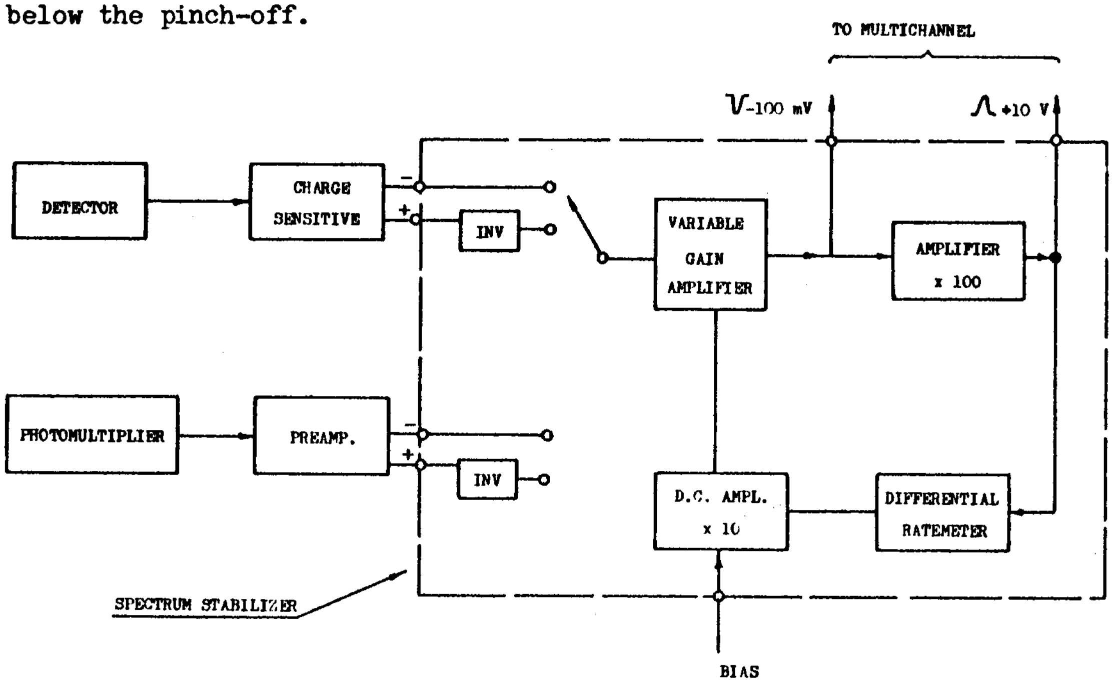

Fig. 56
Block diagram of stabilization system

The results measured on a 512 channel pulse height analyser are as follows:

Stabilization factor: for changes in input amplitude up to a factor of 2.5, the peak position remains in the same channel.

Long term stability: about 1 channel per day.

Temperature stability: 1 channel over a range of 30°-$55^{\circ}C$.

Hunting effect (smearing): about 10% of the initial peak

Dynamic response: faster than 1 sec

A number of units were built and are in use.

A digital instrument which includes the changes of the multichannel analyzer in its stabilization loop, is now under development.

References:

1. DE WARD, H. Nucleonics 13, 36 (1955)
2. Cosmic Rad. Lab., RSI, 33, 1137 (1962)

Computation of the Fourier Transform in a Digital Differential Analyzer[1]:

A. Senator

The Fourier transform is of special importance in many problems of mathematical analysis. Several methods have been proposed for computing the Fourier transform with the help of digital and analogue computers. The present work describes how the problems can be solved on the digital differential analyzer (DDA)[2]. The proposed computation system consists of an interpolator of Lagrange, connected to an oscillator described by the weighting function w(t):

$$w(t) = \sin \omega t$$

The speed and accuracy of computation is high and can be compared with the speed of a general purpose computer (8 minutes on the DDA compared with 1 minute on the G.P.C.).

References:

1. SENATOR, A., M.Sc. Thesis submitted to the Technion, Haifa, November 1955
2. SHANY, A. and KAMIL, Z., A Versatile Incremental Computer, 6th Annual Conference on Aviation and Astronautics, Feb. 24-25, 1964, Tel-Aviv and Haifa

Waveform Generator for a Mass Spectrometer : I. Ben Nun

A generator has been designed and built to supply slow sawtooth and triangular voltage waveforms.

The instrument includes:

(i) A stable voltage pedestal supply with an adjustable range of 0 to 100 V. This pedestal is needed in order to set a rough level from which to start a slow scanning sweep of 10 V.

(ii) A 0-100 V scanning sweep for searching for the proper pedestal level.

(iii) A very stable linear sweep, 10 V high, which "rides" on the selected pedestal.

An electrometer tube is used at the input stage of a Miller integrator. The reference voltages are temperature compensated.

The generator gives sweep times of 10, 100 and 1000 seconds, and the integral linearity and long-term stability are better than 0.2%.

Upper Audio-Frequency Heat Supply for a Mass Spectrometer : I. Ben Nun

Mass spectrometer measurements can be made more accurate by heating the ion source filament with frequencies in the range 10 to 30 kc/s, rather than with DC[1]. A supply was designed using a "resonant capacitor commutated SCR inverter"[2]. The basic circuit is an underdamped series resonant circuit in which the resistive component is the filament to be heated. When the SCR gates are triggered, alternating positive and negative half sine wave current pulses flow into the load. If both gates are triggered by the same source at a frequency twice the resonant frequency, the output is as shown in Fig. 57a. If the triggering frequency is decreased, the output is as shown in Fig. 57b. This variable current-pulse frequency provides smooth power control to the filament heating. The output power of the instrument is variable between 0 and 100 watt at an efficiency of 75%.

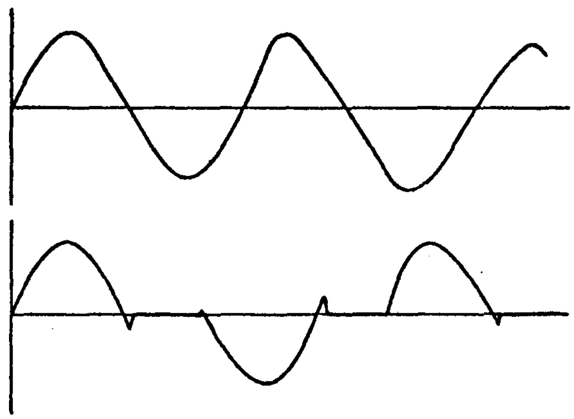

Fig. 57
Output of mass spectrometer heat supply.

References :

1. Advances in Mass Spectrometry, ed. Waldron J.D. p.473, Vol.I, Pergamon Press
2. SCR Manual, General Electric Comp., Auburn, N.Y., p.161

Linear Heating System for Crystals : M. Sidi

In certain solid state physics experiments it is necessary to heat a crystal linearly with time in order to search for energy lines. An instrument was designed to provide linear heating from $-200^{\circ}C$ to $+400^{\circ}C$ over a period of one hour. One of the main problems is the sensing element which must respond linearly to temperature changes, Another problem is the speed with which the transducer responds when energy is transferred to the heating element.

The body to be heated is included in a servo loop. A voltage ramp is provided to the input of the system. Because of the nonlinearity of the sensing element, some compensation is needed at the ramp voltage. The block diagram of the whole system is given in Fig.58 and the block diagram of the ramp generator in Fig. 59 . The latter circuit is basically a dynamic integrator with a quasi-ideal current source feeding a Mylar capacitor of 10 µf. When the switch is opened the capacitor C charges through R (1000 Mohm). The output is

$$e_o(t) = \frac{EA}{RC}\left(t - \frac{1 - A}{RC}\, t^2 + \frac{(1 - A)^2}{(RC)^2}\, t^3 + \ldots\ldots\right) \qquad (1)$$

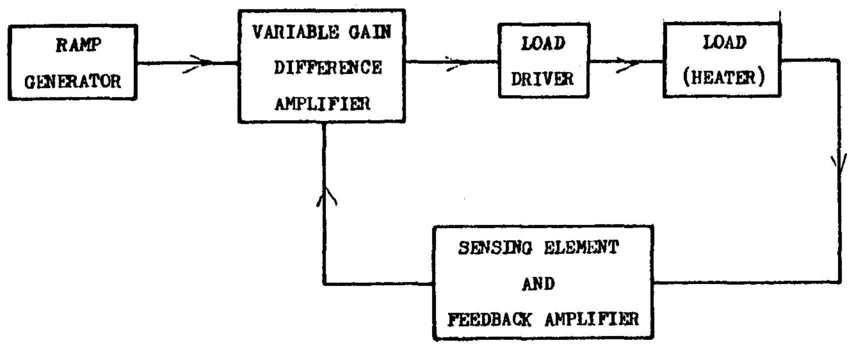

Fig. 58
Block diagram of linear heating system.

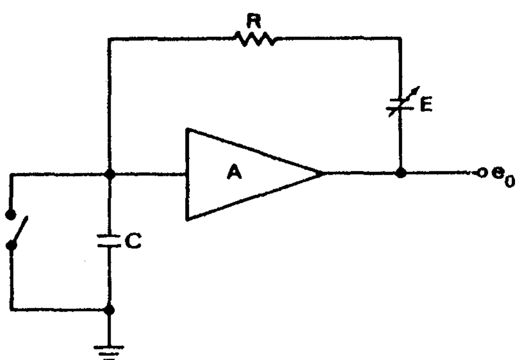

Fig. 59
Block diagram of ramp generator. E is a DC variable voltage supply.

The term $\frac{1 - A}{RC} t^2$ in expression (1) partly compensates the nonlinearity of the sensing element which displays similar square components. This circuit provides a linear ramp of 1 V with 0.7% nonlinearity over a period of one hour. The load driver uses SCR's which change the power supplied to the heating element by changing the phase of the firing. The load itself has the form shown in Fig. 60 . The cryostat is held at high vacuum. The heater wire can provide 300 W. The sensing element is a 10 ohm platinum wire. The feedback amplifier is a low drift D.C. amplifier with a gain of 100. The variable gain difference amplifier has a gain of from 25 to 200 with a common mode rejection of 10,000:1.

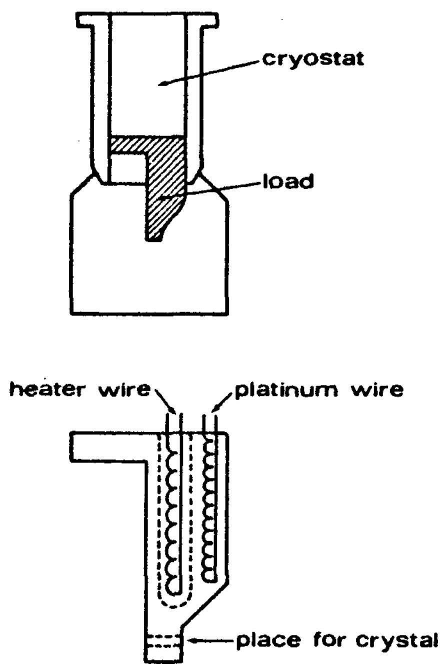

Fig. 60
Load and sensing element

The overall result was 1% integral linearity of temperature at the output, for heating from -200 to +400°C during one hour.

Parity Check for the 3 Dimensional Multichannel Analyzer : M. Sidi

A parity checking device was designed and built for the existing 3-dimensional pulse height multichannel analyzer(1). The information for the analyzer is stored on punched paper tape, each event being recorded in four rows of 8 bits each. In order to make sure that the mechanical perforator is working properly a parity check is needed. The check is on those bits having binary values 2^2 to 2^7.

The circuit has three inputs, A, B and C (Fig.61), and one output, defined as follows:

$$0 \text{ Volt} \equiv 0$$

$$-12 \text{ Volt} \equiv 1$$

If there are one or three inputs (1) the output is (0). If there are two inputs (1) the output is (1).

The circuit described in the figure below is designed with a minimum number of active devices. Immunity to power supply variations is ± 7% of ± 12 V.

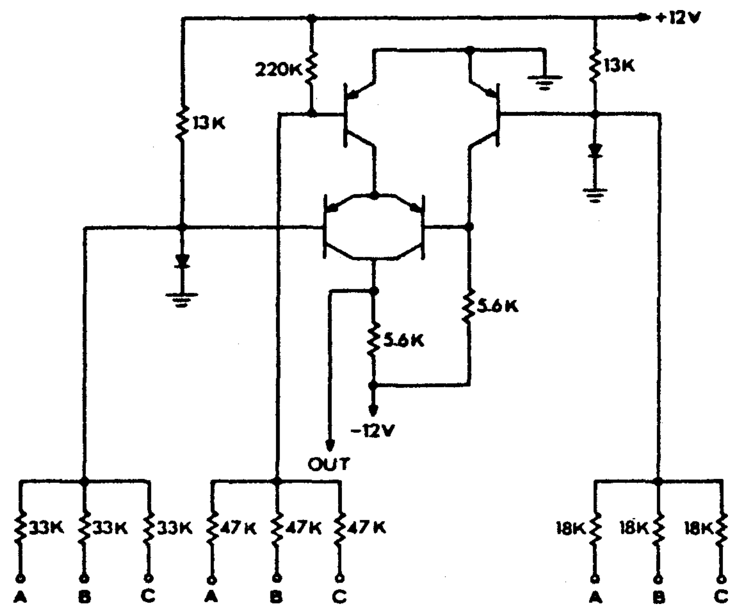

Fig.61

Parity check circuit

Reference:

1. SIDI, M. and FABIAN, Z., Israel AEC Report IA-900, p.161

Capacitance Bridge for Semiconductor Detectors : I. Zadicario and L. Tepper

A bridge was designed and built for the measurement of detector capacitance as a function of the applied bias voltage. It is particularly intended for use in the production of lithium drift type diodes. The bridge has three ranges : 0 - 10 pf, 0 - 100 pf and 0 - 1000 pf. The leakage currents tolerated in each range are 100 μA, 1 mA and 10 mA respectively. Maximum voltage rating is 600 V and accuracy better than 2%.

Portable Linear Ratemeter : I. Zadicario

A portable ratemeter has been designed, intended for monitoring and surveying purposes. There are four linear ranges: 0 - 30 cps, 0 - 300 cps, 0 - 3000 cps and 0 - 30000 cps. The time constants are internally adapted for the different ranges. The accuracy is better than 2% and the stability better than 10%. Sensitivity is 0.5 V negative. The instrument also contains a stabilized power supply (1200 V - 50 μA) for photomultipliers.

Fast Solid State Light Pulser : M. Sidi and L. Tepper

The characteristics and possible uses of a fast light emitting device were investigated.

The device is a Fairchild FSP-103 diode emitting a light pulse with a 1 nsec risetime, when pulsed into avalanche. The number of photons emitted is estimated at 100 when a 10 A pulse is delivered into the diode. This number increases with the current. The schematic circuit used for the excitation of the diode is shown in Fig. 62.

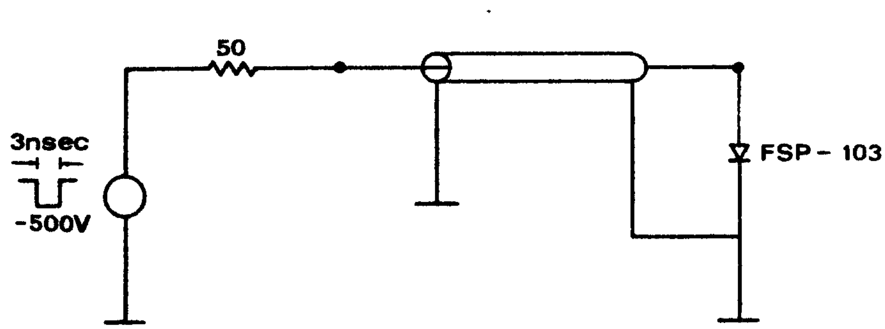

Fig. 62

Schematic circuit for light diode excitation

The light emission was measured with a 56 AVP photomultiplier operating at 2000 V. The spread in current amplitude at the anode of the phototube was about 20% of the minimum; the time spread was 0.35 nsec with the diode coupled directly to the tube, and 0.5 nsec with a scintillation crystal in between. The rise time of the pulse was about 4 nsec, the fall time 8 nsec.

It is thought that this type of diode may be very useful for the alignment of several photomultipliers with respect to signal propagation delay. Another possible use could be the focussing of fast phototubes.

Instrumentation for a Pulsed Nuclear Magnetic Resonance System :

J. Hershkovitz

In pulsed N.M.R. experiments, a sample is inserted in an intense DC magnetic field for the purpose of tipping the nuclear spin system by means of a massive RF pulse which lasts for a very short time. A short-lived free induction decay signal is thus produced and has to be recorded without noise or distortion.

A system was set up for this experiment. Some of the instruments required were bought and others were designed and built here. The system includes:

(i) A large magnet with a magnetic field of 26 kgauss, very well stabilized by means of a "Hall effect" element.

(ii) A transmitting system in the range of 2-30 Mc/s with a pulsed output of 5 kW, which leads to pulsed circularly polarized RF magnetic fields of the order of 50 gauss.

(iii) A receiving system with a recovery time of 5-10 μsec after the burst of RF field from the transmitter, and a sensitivity limited by thermal noise in the receiving end of the preamplifier. The detection is phase coherent.

The system works as follows. A constant amplitude sine wave generator is the RF source. Its output is split into two channels; one passes through a phase shifter (which controls the phase of the RF field, related to a reference signal), an RF gate (controlled by the pulse generator), and on to the transmitter, while the other goes via an attenuator to one of the two inputs of the receiver, being used there as a reference signal for phase detection. The free induction decay signal and the RF pulse overload are picked up by the RF preamplifier from the receiver coil. A special pulse from the pulse generator (quench pulse) helps to speed up the recovery of the receiver coil from the overload of the RF pulse. The action of the quench pulse is to lower the Q of the receiver coil until the ringing induced by the RF pulse has vanished, after which the Q rises to record the nuclear resonance signal.

In the first stage of the receiver, the free induction decay signal and the reference signal are combined to make possible phase coherent detection. Since the reference signal has a steady and large amplitude compared with the nuclear resonance signal, its rectified output is used for the automatic gain control of the receiver. After the detection of the signal, the video is amplified anf fed to a scope or to a lock-in-detector which improves the signal-to-noise ratio.

<u>An Air Particle Monitoring System</u> : I. Ben Nun and D. Boger

An environmental radiation monitoring station has to give a continuous indication of the activity of particles in the atmosphere. It must distinguish between normal activity and unusual activity resulting from special events like fresh fallout, etc. Due to the large variations in the normal activity, reliable measurements require averaging over long periods, leading to a delay of many hours before the results can be obtained. However this problem can be overcome by measuring the ratio of beta to alpha activity, which remains constant for normal activity.

A monitor C.R.C. 620 was modified and adapted to perform the ratio measurements. The output recorded is proportional to

$$\alpha + \beta - (k + 1)\,\alpha$$

where $\alpha \equiv$ integrated α radiation, $\beta \equiv$ integrated β radiation, $k \equiv \frac{\beta}{\alpha}$. For normal activity the output must be zero. The instrument was tested in several week-long runs and no significant departure from zero was detected, although there were tenfold increases in natural activity during every 24 hour period.