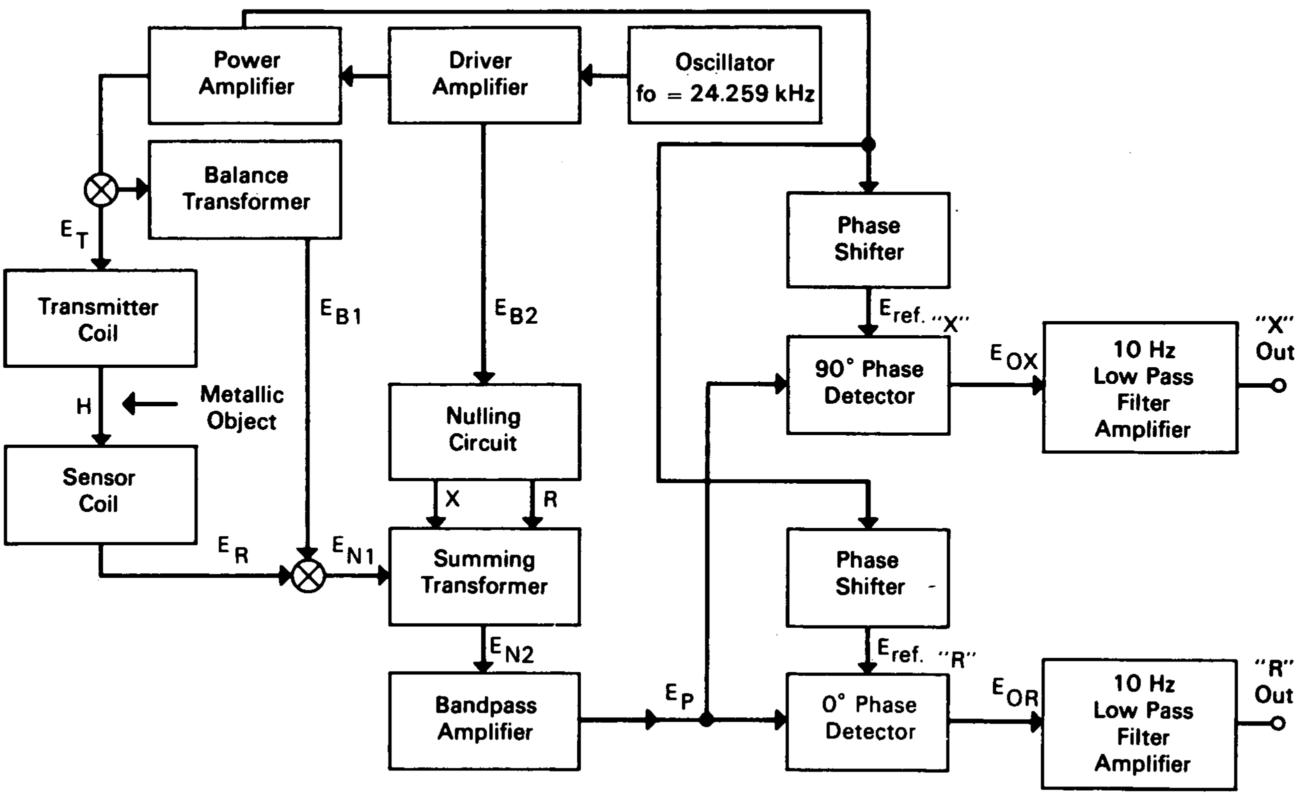
NASA TECH BRIEF

Metal Detector System



Preliminary Block Diagram for Metal Detector

The problem:

To design a detector which can perform an inconspicuous search of personnel moving into areas where metallic objects are prohibited.

The solution:

The detection and identification of ferrous and nonferrous metallic objects is accomplished with a phase-sensitive (polarity) detector. The signal voltage resulting from the disturbance of an electromagnetic field within the volume of a sensitive area is compared with a reference ac voltage for polarity information, which identifies the material. The system output amplitude and polarity indicate the approximate size and type of metal, respectively.

How it's done:

The system (see block diagram) operates as follows: the oscillator provides an ac voltage at 24.259 kHz for the driver and power amplifiers. The power ampli-

(continued overleaf)

fier feeds an ac voltage E_T to the transmitter coil, which sets up a magnetic field. The sensor coil is located 3 to 4 feet from the transmitter coil, with its plane parallel to that of the transmitter coil. The sensor coil therefore links the transmitter coil field, H, and develops a signal voltage, E_R, which is summed with a voltage, E_{B1}, from the balance transformer connected in series with the transmitter coil. The ac voltages E_R and E_{B1} are of opposite phase, and when they are summed, the result is a small residual voltage, E_{N1}. The summing transformer adds E_{N1} to E_{B2} with the nulling circuit providing both correct phase and amplitude of E_{B2} to form a null at the output of the summing transformer. The summing transformer voltage E_{N2} is coupled to the bandpass amplifier which has a center frequency identical to that of the oscillator. The bandpass amplifier drives the 90° or "X" phase-sensitive detector and the 0° or "R" phase-sensitive detector. The reference voltage for the phase detectors is provided by the power amplifier through a separate phase shifter for each detector circuit. The phase detector outputs are dc voltages (E_{OX} for the 90° detector and E_{OR} for the 0° detector). The amplified voltages E_{OX} and E_{OR} are filtered and amplified by a pair of 10-Hz low-pass-filter amplifiers. The amplifier outputs are displayed on a two-channel recorder that indicates a dc voltage level near zero for an undisturbed field, H. A ferrous object passing between the two sensor coils will disturb the magnetic field, H, and cause an amplitude increase in the sensor coil signal voltage, E_R. The increase in E_R unbalances the summed voltages in the balance and summing transformers. The change in E_{N2} having the same phase polarity as E_R, is amplified to voltage E_{PF}. For ferrous objects, E_{PF} increases the dc voltage of the phase-sensitive (polarity) detectors E_{OX} and E_{OR} from their ambient levels. These amplified and filtered positive dc voltages represent a ferromagnetic object disturbing the field, H. The magnitude of the dc change from the ambient level is proportional to the permeability, size, and geometry of the object.

The duration of the dc change depends on the length of time the metal object remains between the sensor coils; the voltages will return to their ambient dc levels when the metal object passes through the region linking the two coils.

A nonferromagnetic object between the detector coils will absorb energy from the field, H, and cause an amplitude decrease in E_R, unbalancing the summed voltages in the balance and summing transformers. The change in E_{N2} is amplified to E_{PN}. The phase polarity of E_{PN} causes the phase-sensitive (polarity) detector dc voltages E_{OX} and E_{OR} to decrease from their ambient dc levels. The 10-Hz low-pass-filter amplifier will filter and amplify these negative dc voltages which represent a nonferromagnetic object disturbing the field, H. These negative voltages deflect the recorder pen as long as the nonferrometallic object remains between the coils.

Notes:

1. The detector is insensitive to metal objects below a certain size, typically coins, watches, and pens.
2. The output amplitude is substantially independent of the speed at which the metal object moves through the detector system. System output may be signalled by colored lights, an aural alarm, or a chart recorder.
3. Requests for further information may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: TSP70-10511

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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