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LOCATING GROUND FAULTS ON STATION BATTERY SYSTEMS

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Described in this paper is a proposed station battery system ground fault detector and locator. The proposed detector-locator can be fixed or portable and is designed to trace high resistance grounds on battery systems without sectionalizing the battery system.

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INTRODUCTION

Detecting Battery Grounds

There are several ways which can be used to detect or trace battery grounds. These can be divided into D.C. and A.C. operating systems.

D.C. Method

The D.C. system typically uses the battery itself as a source of power. A high impedance voltmeter is used to measure the voltage to ground of the positive terminal and then the negative terminal. From these two readings, the resistance of the voltmeter, and the battery voltage, the leakage resistances from each terminal to ground can be calculated.
Note that three readings (battery voltage, V+ to ground voltage, and V- to ground voltage) and a constant (Meter resistance) are required to determine leakage resistance. The leakage resistance ranges are determined by the voltmeter resistance and can typically cover a range of infinity to a few hundred ohms with a 10,000 ohm voltmeter.
This system is very sensitive and very useful for detecting, and measuring high, or low resistance grounds. The system is, however, useless as far as locating the ground is concerned. The only practical method is to sectionalize the battery system while watching the ground detector signal. The sectionalizing method of locating grounds, is typically very time consuming and tedious.

A.C. Method

The simple A.C. method consists of applying an A.C. voltage between ground and the battery system and then measuring the A.C. circuilating currents. These currents are typically measured with clamp-on sensors. It should be noted that the resulting A.C. current consists of two components, that is the capacitive changing current and the leakage current. If the capacitive current is large, such as present on large battery systems, then locating a high-resistance ground is difficult. An advantage of this method is that the A.C. signal can be injected at different points on the system. In this manner a portion of the capacitive charging current can be diverted improving the sensitivity of the system. This action, however, requires additional time during ground location process.

An improvement over the simple A.C. method is to use a wattmeter instead of an ammeter as the current sensor. The wattmeter can be considered to be a phase and direction sensitiver ammeter in this application. Being phase sensitive it can differentiate between the charging current of the battery system capacitance and the leakage currents. Because of its directionality it can actually "point" towards the location of the ground.

Because A.C. currents can be measured in different branches, the A.C. method is capable of tracing and locating multiple grounds.

Grounded Systems

For a variety of reasons some battery systems are grounded by means of a resistor of high value, typically 10,000 ohms. This grounding resistor reduces the sensitivity, and unbalances the D.C. type ground detector. It does not, however, affect the operation or the sensitivity of the A.C. type ground detector-locator.

COMPARISON OF DETECTORS

D.C. Detector

Advantages:
- accurate (±5% of calculated value).
- sensitive (typically 1M ohm).

Disadvantages:
- no locating ability.
- location only by sectionalizing.
- very difficult when tracing multiple faults.

A.C. Detector

Advantages:
- highly versatile as locator.
- sensitive (typically 1M ohm).
- directional.
- traces multiple faults.

Disadvantages:
- not sensitive on solid (low resistance) grounds.
- requires access to both (+) and (-) leads of battery system.

THE PROPOSED INSTRUMENT

A block diagram of the proposed battery ground detector-locator is attached. The transmitter portion of the instrument consists of an oscillator, amplifier, and a blocking capacitor that injects an A.C. signal on the battery system. The detector portion of the instrument consists of a clamp-on current sensing transformer, which measures the currents injected in the branch circuits of the battery system. The injected A.C. signal voltage on the battery leads is also measured and is used in the locator's detector circuitry.
The locator circuitry includes amplifiers tuned to the injected A.C. signal, as well as a multiplier (wattmeter) whose output is proportional to the watts dissipated in the branch circuits at the injected A.C. signal frequency. The wattmeter output, is proportional to the power dissipated in the branch circuit's resistance to ground. It is used to trace the unwanted battery ground.
The selection of the signal frequency is very important. The choosen frequency should be such that:

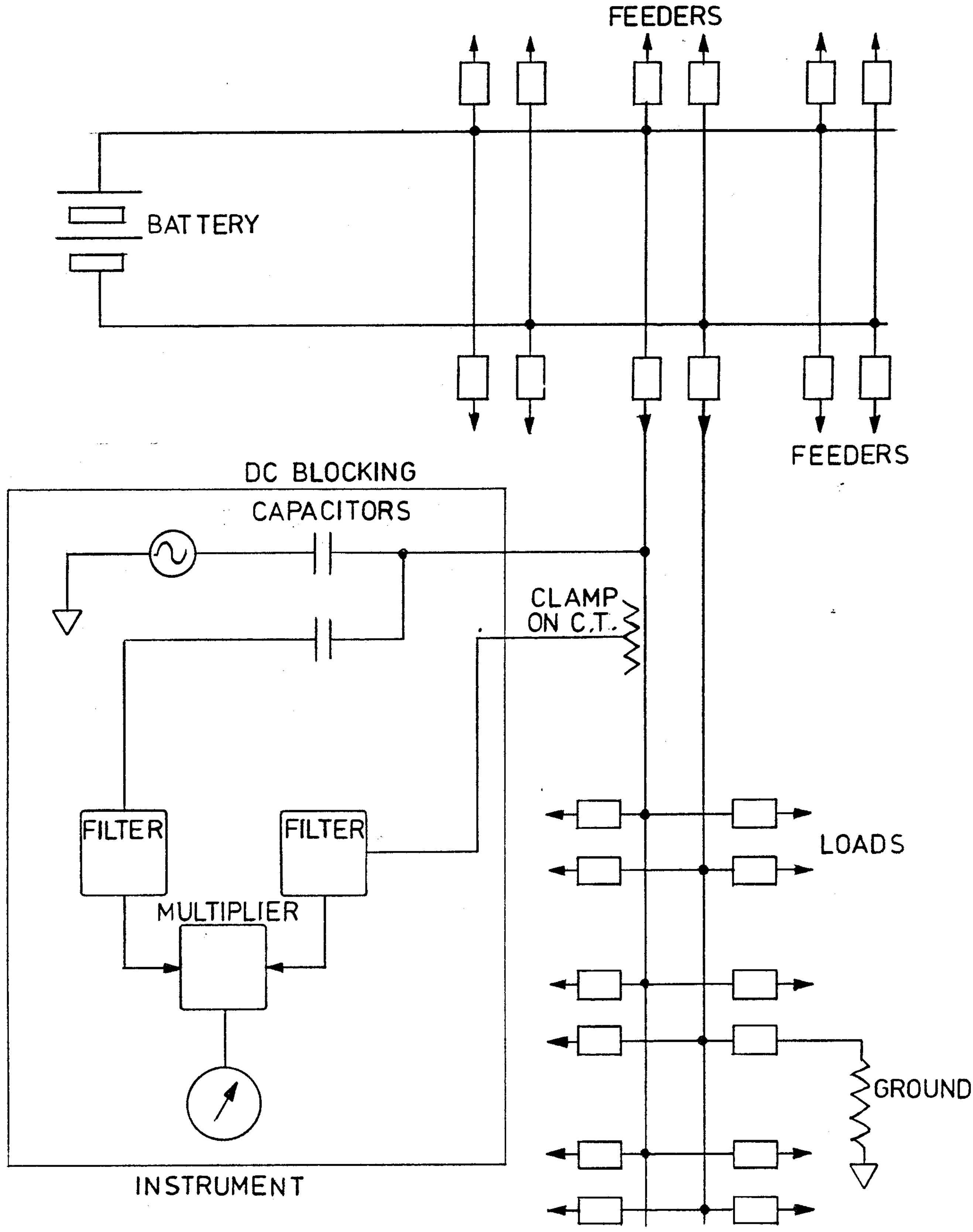
a. The ratio of the current due to a high-resistance ground, to the current due to stray capacitance is high or a maximum.
b. Adequate current sensors can be made for the frequency.
c. The power frequency and its harmonics do not interfere with the operation of the locating equipment.

Items a and b suggest that the lowest frequency for which reasonably accurate current sensors can be built should be used. Item c indicates that the frequency should be removed from the power fre-

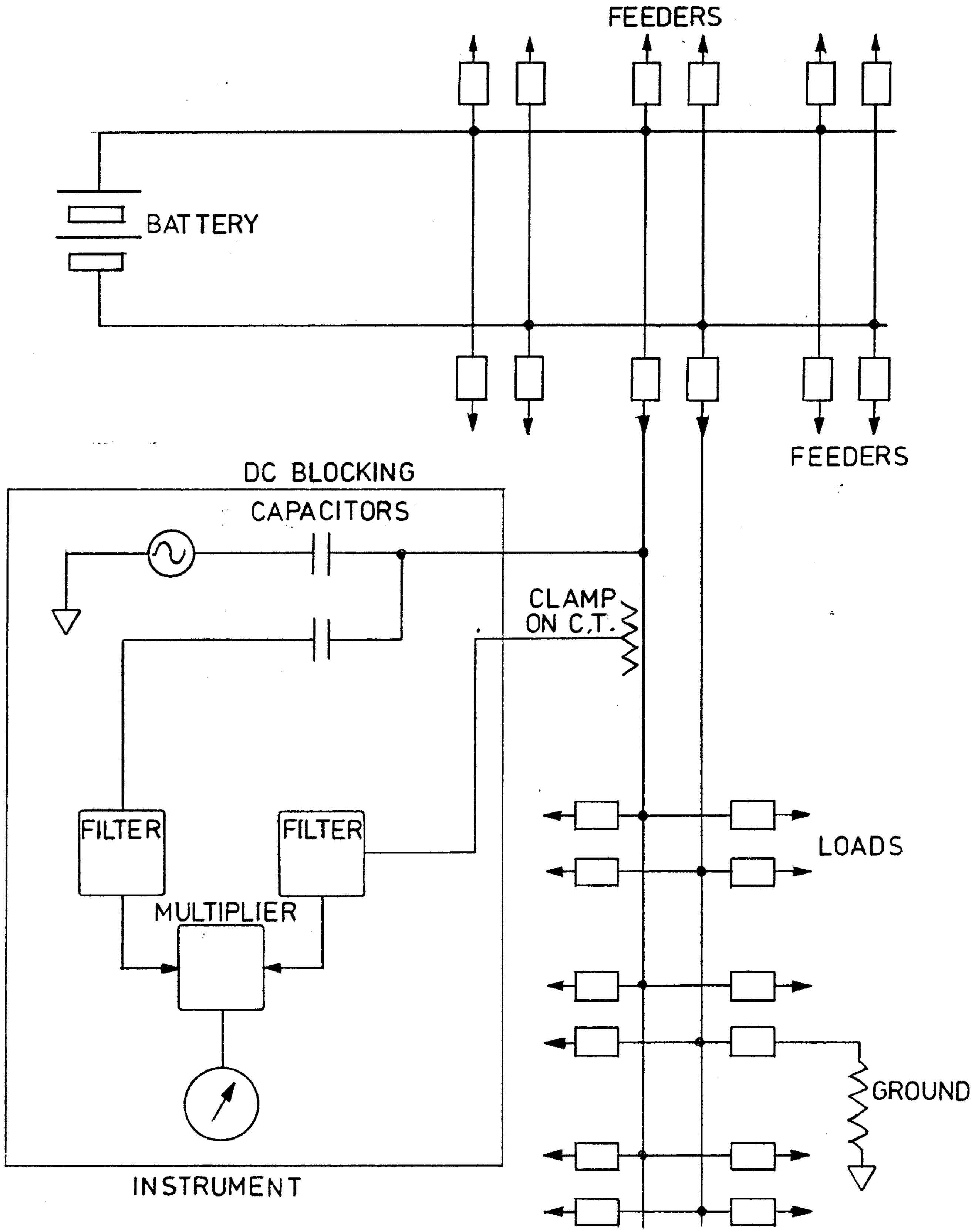
quency and its harmonics.
The detector can be portable or fixed. Fixed detectors can be installed on each branch circuit to give an alarm when a ground occurs on that circuit. The portable detectors would be most useful in tracing the ground among the various loads connected to the affected branch circuit.

DISCUSSION

The battery ground detector described in this report operates on a different principle than the battery ground detectors used by utilities in their stations at the present time. The chief advantage of the proposed detector is that it can be used to trace and locate grounds on the battery system without sectionalizing.
The success or failure of the proposed detector hinges on the availability of suitable clmap-on current sensors that would be capable of sensing fractions of milliamperes of signal current in the presnece of large D.C. current, as well as 60Hz power currents and its harmonics. Measurements conducted on at least one commercial clamp-on current transformer indicate that it may be suitable for use at small currents and at frequencies as low as 10Hz if it is suitably compensated and amplifier aided. Clamp-on C.T.s of this type would make it possible to operate the ground detector system at frequencies below the power frequency.
Assuming a frequency of 20Hz, measurements on the clamp-on C.T. indicate that there should be no difficulty in detecting a ground resistance of 100 k ohms in the presence of 1 microfarad stray lead capacitance. The signal injected on the battery system would have to be in the range of 10 to 50 volts, depending on the noise on the system. These voltage levels indicate that the injecting amplifier would have to deliver about one volt amperes to excite large battery systems. The above power level indicates that portable self-contained battery powered instruments are quite realistic.



BATTERY GROUND DECTECTOR-LOCATOR



BATTERY GROUND DECTECTOR-LOCATOR