

**(12) United States Patent
Philipp**

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- (54) **CHARGE TRANSFER CAPACITANCE MEASUREMENT CIRCUIT**
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- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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- (22) Filed: **Sep. 7, 1999**

Related U.S. Application Data

- (60) Provisional application No. 60/109,889, filed on Nov. 25, 1998.
- (51) Int. Cl.⁷ **G01R 27/26**
- (52) U.S. Cl. **324/678; 324/658**
- (58) Field of Search **324/678, 658, 324/661, 663, 665, 676, 679**

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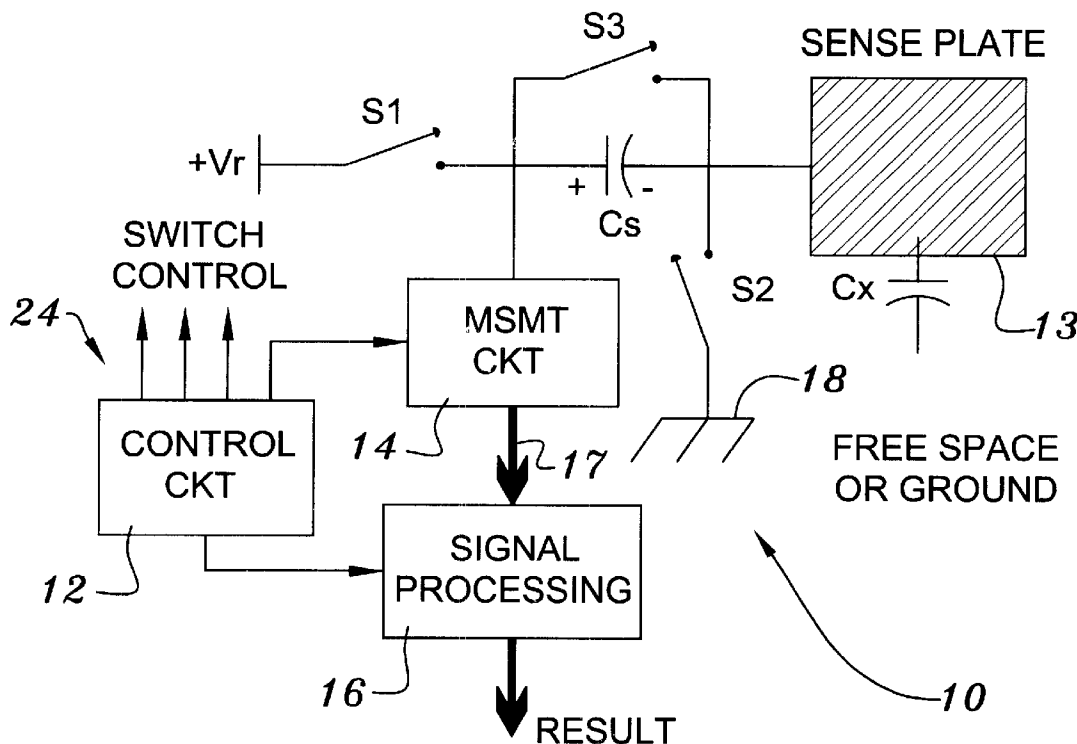
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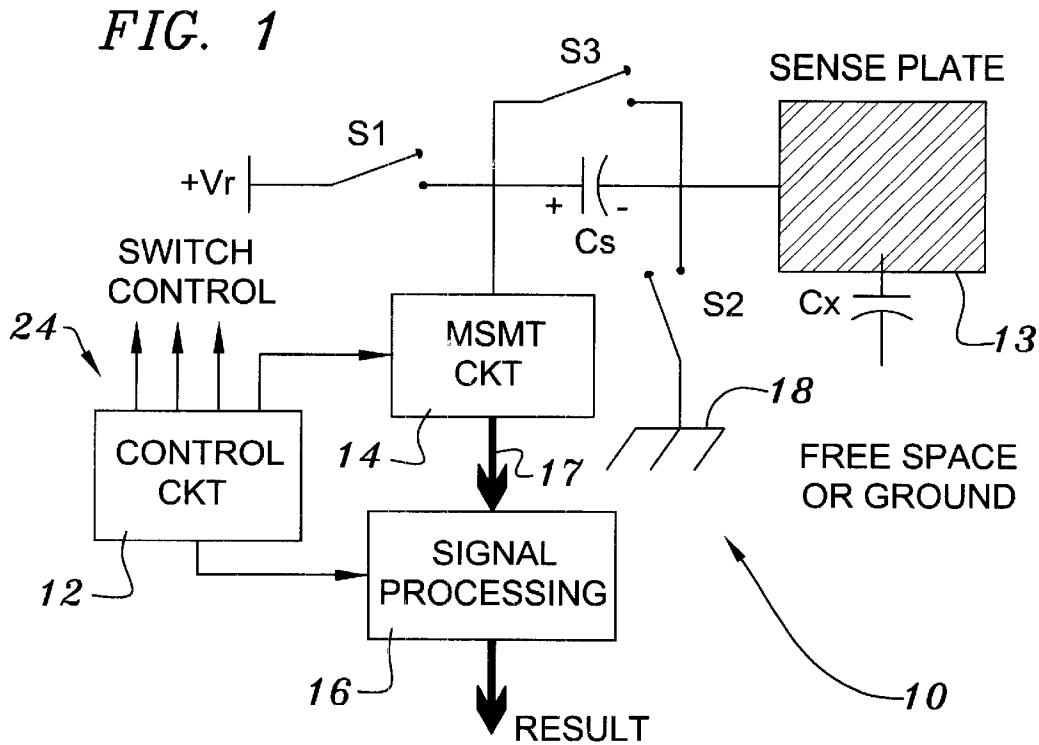
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(57) ABSTRACT

Pulse circuits for measuring the capacitance to ground of a plate may be used in control equipment to provide an indication of the proximity of a person or object to be sensed. Pulse circuits are disclosed that are made from sets of three or more electrical switching elements arranged so that each of the switching elements has one side electrically connected to either a supply voltage or to an electrical ground. These arrangements are compatible with existing integrated circuit fabrication technology. In addition, the circuitry can be configured as a proximity sensing switch that requires only a two wire connection to a host apparatus.

39 Claims, 14 Drawing Sheets





| | STEP | S1 | S2 | S3 | FUNCTION |
|------|------|----|----|----|-----------------|
| LOOP | A | - | X | X | RESET ALL |
| | B | - | - | - | DEADTIME |
| | C | X | - | - | CHARGE-TRANSFER |
| | D | - | - | - | DEADTIME |
| | E | - | X | - | HOLD |
| | F | - | X | - | MEASURE |

FIG. 2

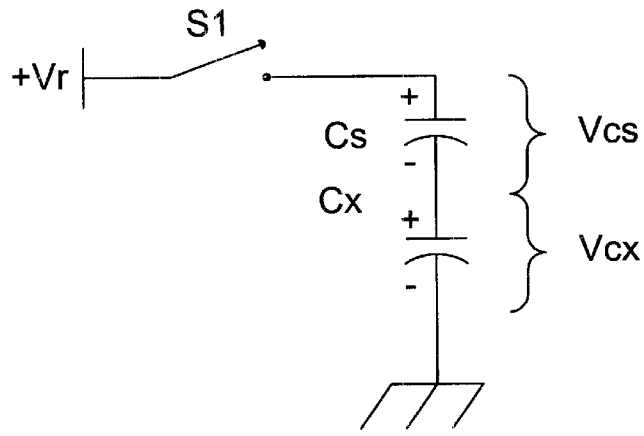


FIG. 3

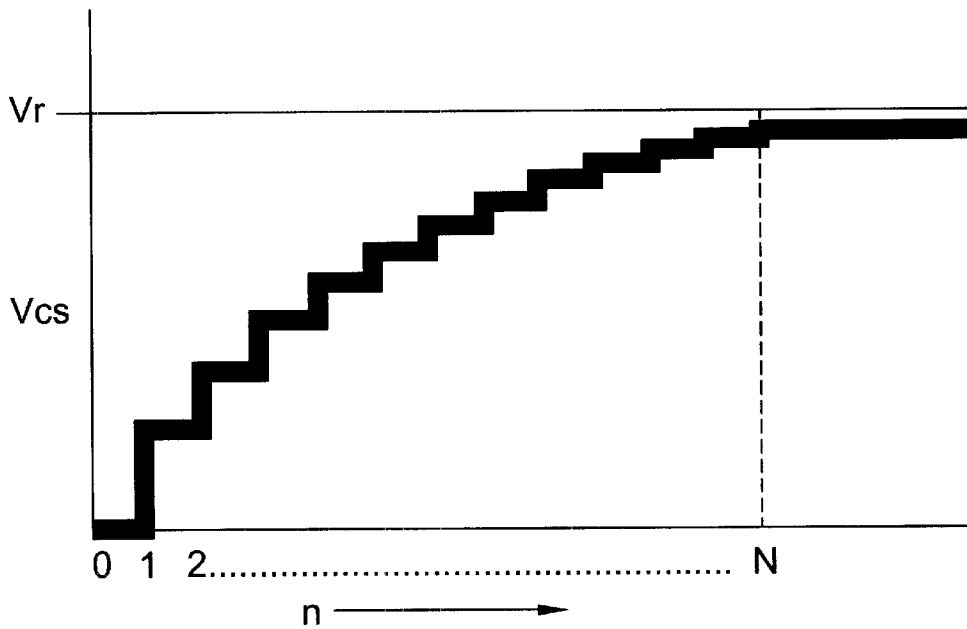
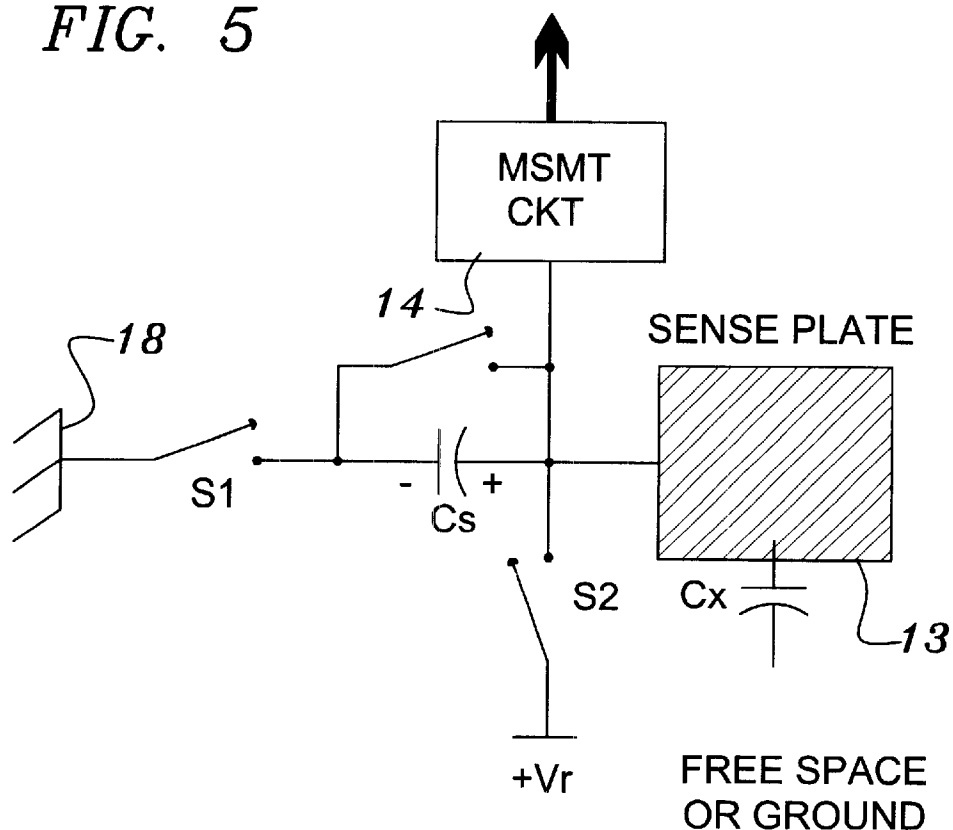


FIG. 4

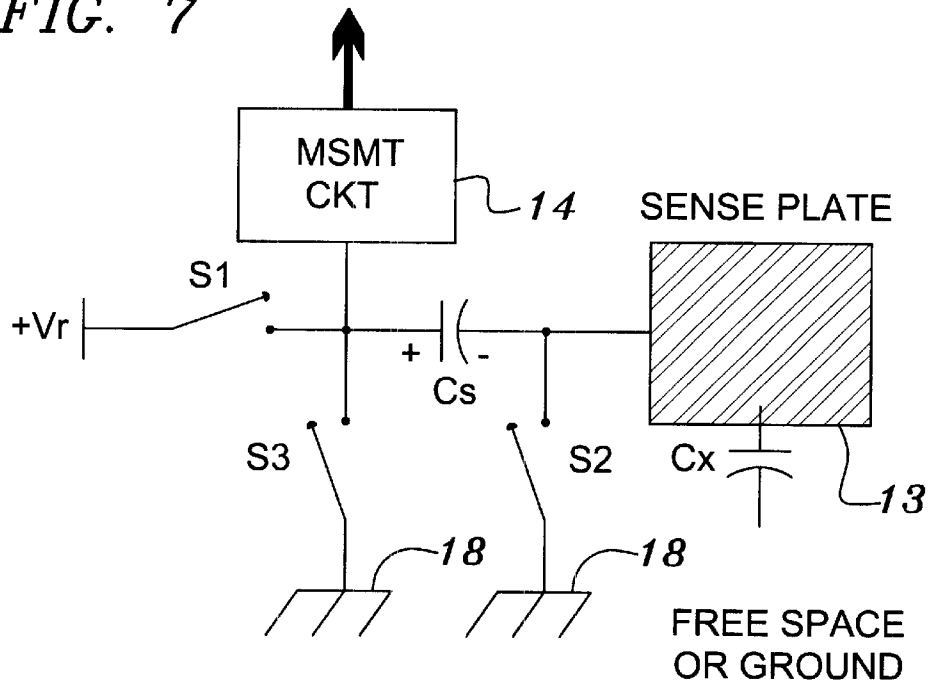
FIG. 5



| | STEP | S1 | S2 | S3 | FUNCTION |
|------|------|----|----|----|-----------|
| | A | X | - | X | RESET ALL |
| LOOP | B | - | - | - | DEADTIME |
| | C | - | X | - | CHARGE |
| | D | - | - | - | DEADTIME |
| | E | X | - | - | TRANSFER |
| | F | X | - | - | MEASURE |

FIG. 6

FIG. 7



| | STEP | S1 | S2 | S3 | FUNCTION |
|------|------|----|----|----|-----------------|
| LOOP | A | - | X | X | RESET ALL |
| | B | - | - | - | DEADTIME |
| | C | X | - | - | CHARGE-TRANSFER |
| | D | - | - | - | DEADTIME |
| | E | - | X | - | HOLD |
| | F | - | X | - | MEASURE (HOLD) |

FIG. 8

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