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4/100, 317/246, 317/262 R, 317/DIG. 2

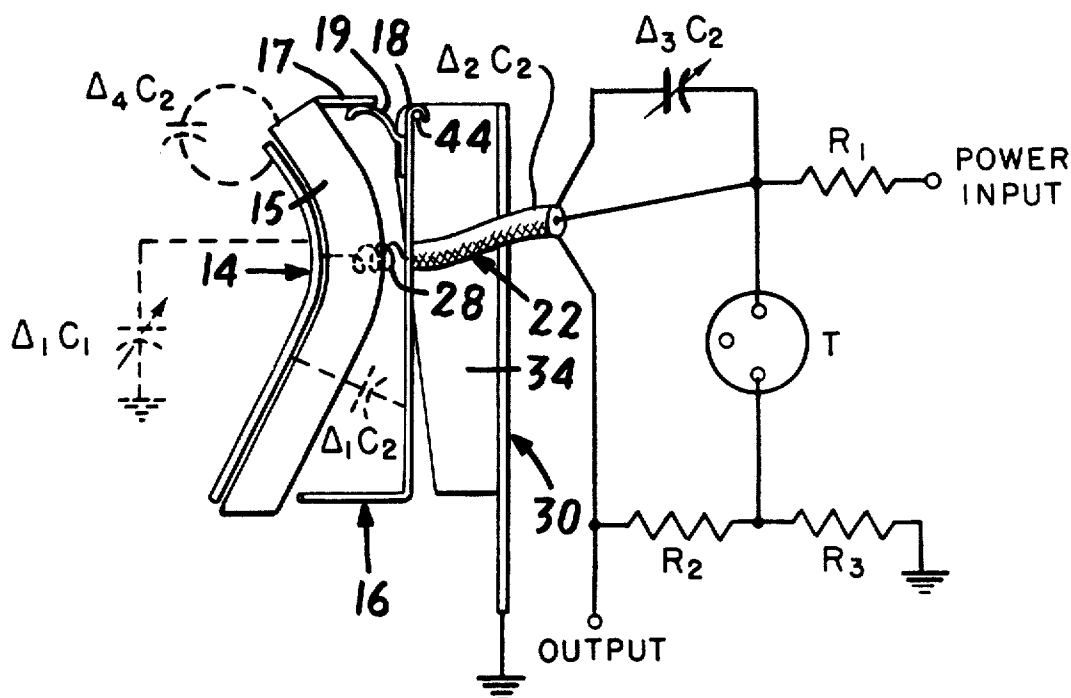
[51] Int. Cl. .... H01g 1/06

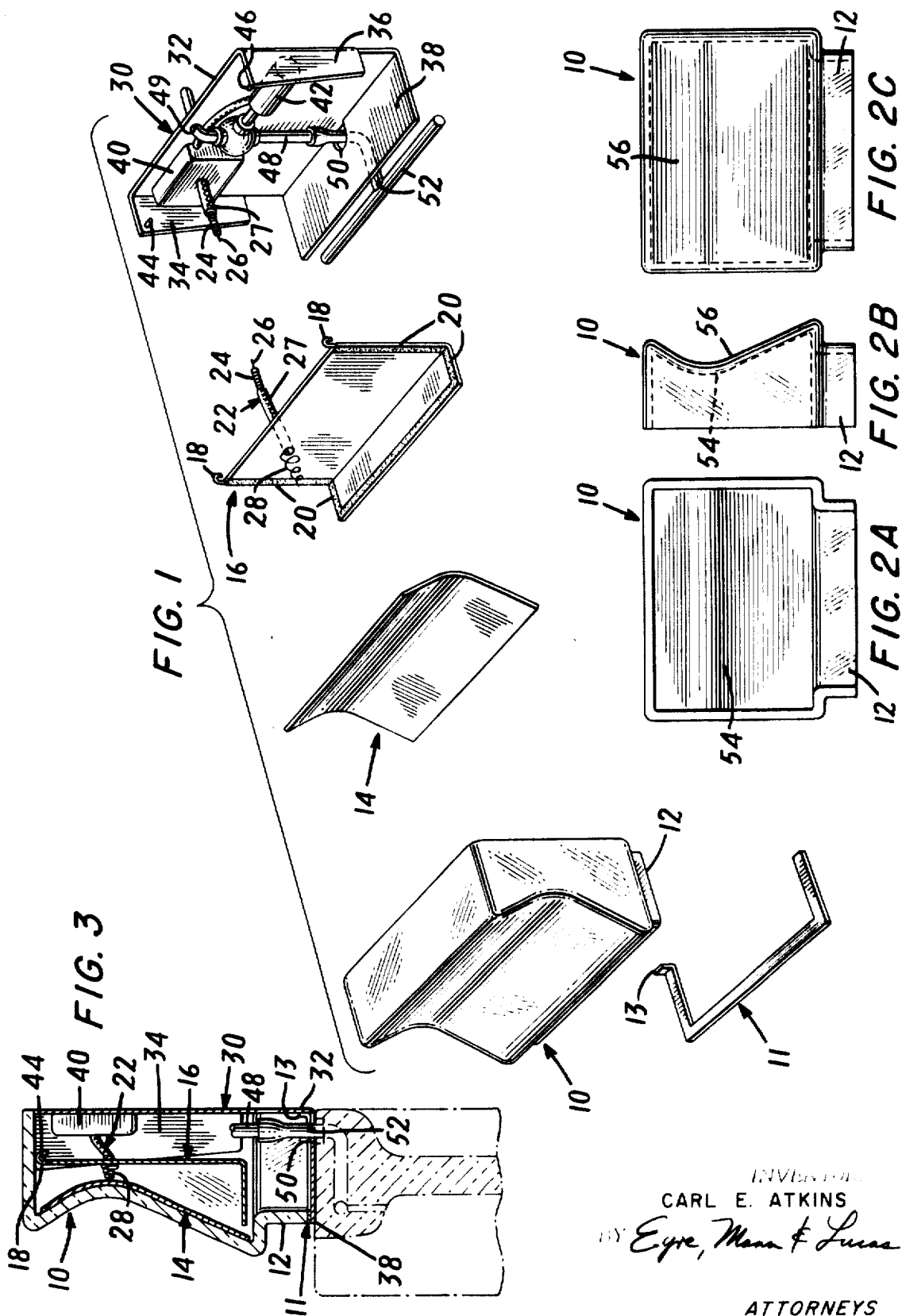
[50] Field of Search ..... 317/256,  
246, 123, 262 R; 4/100; 340/258, 258 C; 328/5

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**ABSTRACT:** Each of two embodiments of an antenna system for capacitance-controlled circuits comprises an antenna member which forms a common plate of first and second capacitances, and a shield for interrupting electric flux between the antenna and grounded elements near the rear surface of the antenna. A first embodiment also comprises a fixed increment of the first capacitance between the antenna and a conductive element situated between the antenna system encasement and the controlled sanitary facility which the encasement abuts. The encasement functions as a dielectric in the aforementioned increment of capacitance, and the conductive element operates to prevent spurious increases in antenna capacitance to ground which result from the intermittent flow of water in the controlled sanitary facility. A second embodiment comprises a conductive element disposed about the periphery of the antenna member and spaced therefrom. This conductive element forms a second plate to the second capacitance, and effectively shields the antenna member from electric fields passing through the encasement.





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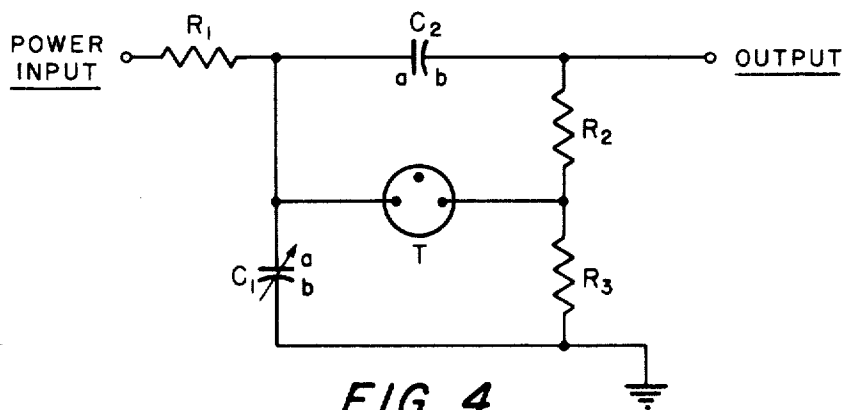


FIG. 4

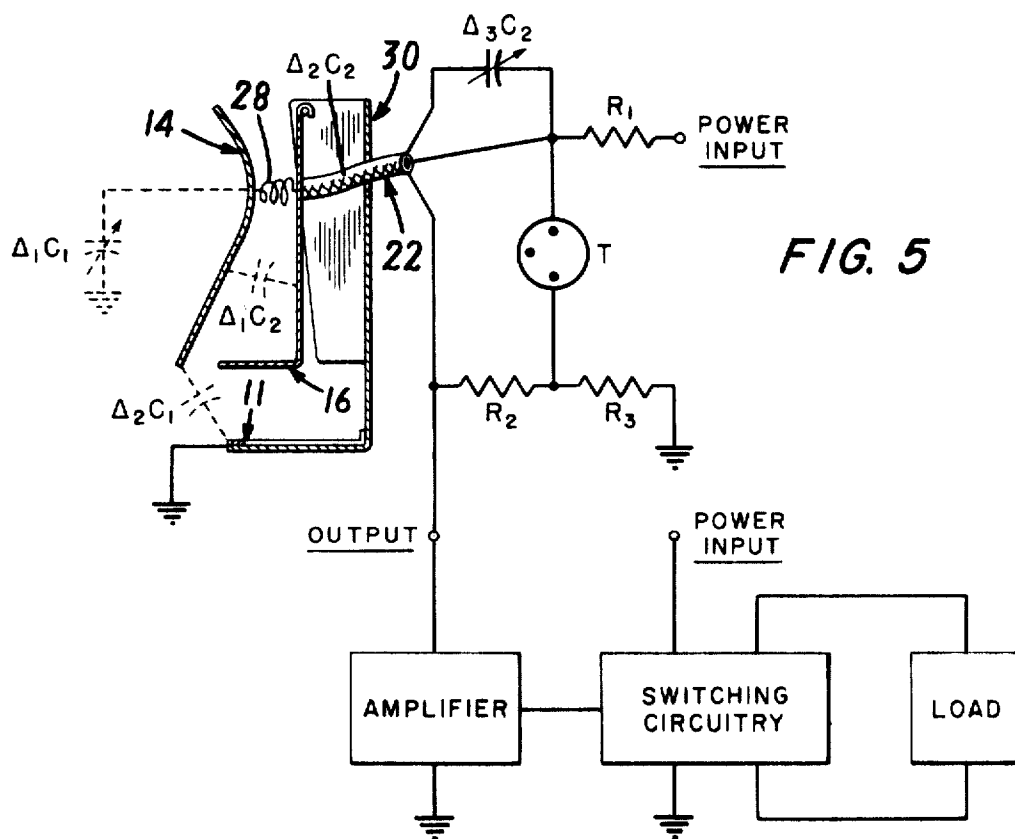


FIG. 5

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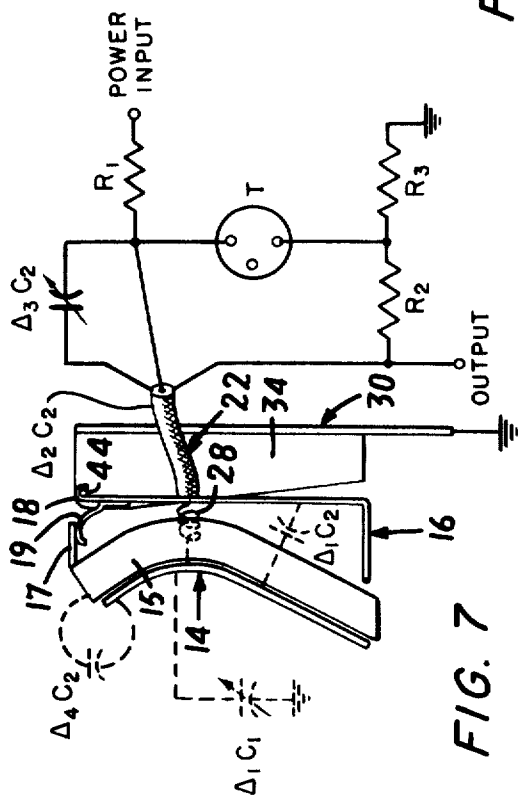
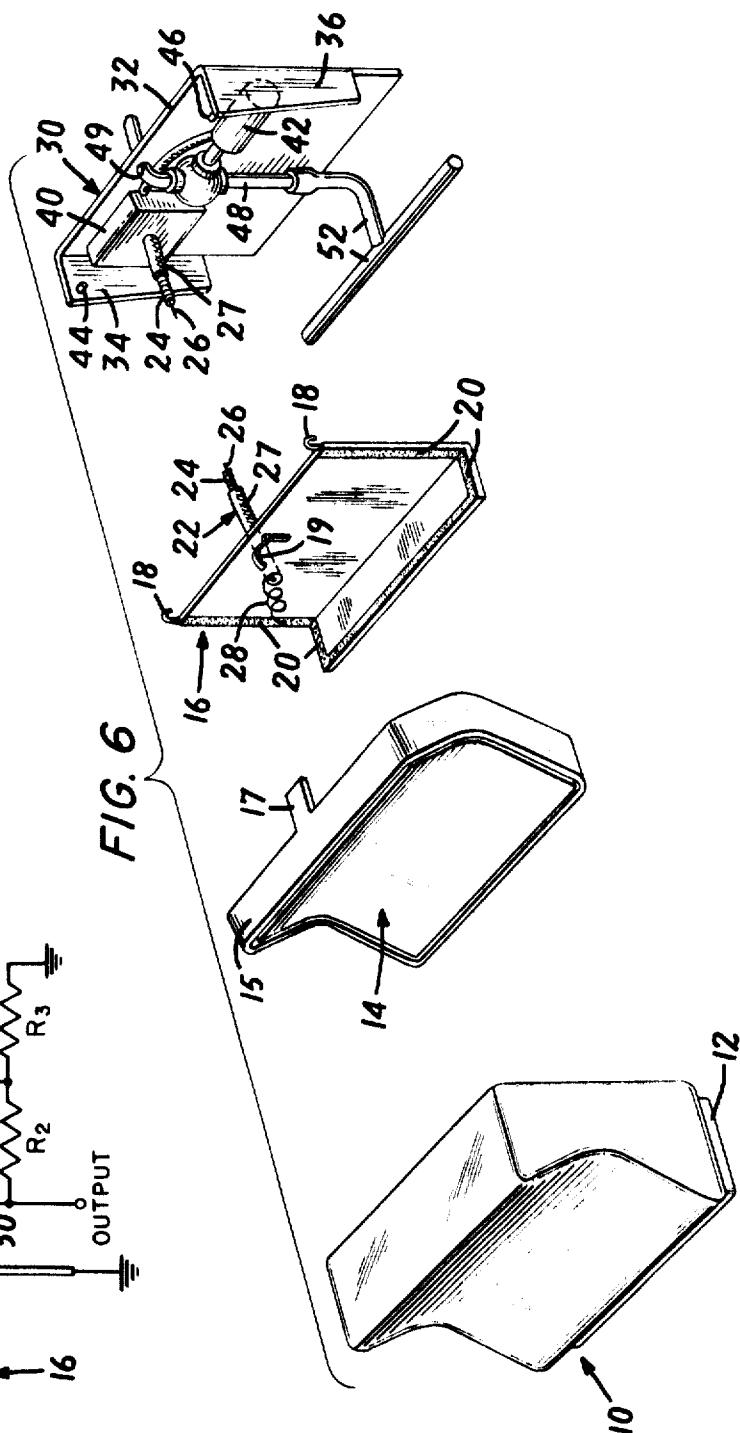


FIG. 6

FIG. 7



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# ANTENNA SYSTEM FOR CAPACITANCE RESPONSIVE CIRCUIT

This application is a continuation-in-part of copending application Ser. No. 674,833 filed on Oct. 12, 1967 by Carl E. Atkins.

The present invention relates to an improved antenna system for capacitance-responsive circuits. The invention is particularly adapted to minimize the signals sensed by the antenna as a result of extraneous events to which the system is not intended to respond. More particularly, the antenna system is adapted for use with urinal installations and is designed to obviate the water curtain problem, i.e., the introduction of an appreciable signal as a result of the flushing operation of the urinal.

The water curtain problem is also dealt with in application Ser. No. 592,825, filed Nov. 8, 1966 and subsequently abandoned in favor of copending continuation-in-part application Ser. No. 795,381 filed on Dec. 13, 1968. This copending application discloses an antenna system which is embedded in the porcelain structure of the urinal. It is desirable, however, to be able to modify existing urinal installations by the addition of proximity control apparatus. In order to facilitate such a retrofitting process, it is desirable to have a modular system which may be installed on the upper ledge of the urinal without making extensive structural modifications to the existing urinal installation. The invention disclosed herein is adapted to permit the entire capacitance control circuit and the flushing valve controlled thereby to be constructed with sufficient compactness to be emplaced on the top ledge of existing urinal installations.

For a better understanding of the present invention and the advantages thereof, the following description of the physical embodiments thereof, the following description of the physical embodiments thereof should be read in connection with the accompanying drawings of which:

FIG. 1 is an exploded view of the first embodiment of the capacitance control system module;

FIGS. 2A, 2B and 2C show the rear, side and front views, respectively, of the encasement of the module;

FIG. 3 is a sectional view along plane 3-3 of FIG. 1 with the module being assembled;

FIG. 4 is a schematic diagram of a low-frequency oscillator circuit in which the antenna system is adapted to be used;

FIG. 5 is a circuit diagram illustrating how the structural elements of the first embodiment of the antenna system and other parts of the module form elements of the capacitance-responsive circuit;

FIG. 6 is an exploded view of the second embodiment of the capacitance control system module; and

FIG. 7 is a circuit diagram illustrating how the structural elements of the second embodiment of the antenna system and other parts of the module form elements of the capacitance-responsive circuit.

Referring now to FIG. 1, the module is enclosed by encasement 10, and has a strip of conductive material 11 which is coextensive with the bottom edge 12. Conductive strip 11 may have a small vertical extension 13. Antenna 14 fits against the forward interior surface of the encasement 10. Shield 16 includes suspension hooks 18 and insulating tape 20 along its bottom and side edges. The coaxial cable 22 extending from the shield 16 comprises an outer conductor 24, and inner conductor 26 and an electrically insulative covering 27. Shield 16 is electrically connected to the outer conductor 24. The antenna 14 is electrically connected to inner conductor 26 by spring 28. The mounting plate 30 comprises a back portion 32, two side portions 34 and 36 and a bottom portion 38. A container 40 for the electronic circuit components and the flushing valve 42 are mounted against the back portion 32. Each of the side portions 34 and 36 include mounting protrusions 44 and 46 from which shield 16 is suspended. The mounting protrusions 44 and 46 electrically insulate shield 16 from the mounting plate 30. The grounded water pipe 48 ex-

tends first through an opening 49 in the back portion 32 and then through an opening 50 in the bottom portion 38, and directs water into a conduit 52 in the upper portion of the urinal. This conduit is usually formed in the structure of the urinal itself, and provides for lateral distribution of the water flow so as to form a curtain on the recessed vertical wall of the urinal. The path of flow of the water is first forward from the rearwardly-situated input connection of the urinal, and then laterally through conduit 52, the conduit having a number of apertures spaced along its length to form a curtain of water.

FIGS. 2A, 2B and 2C illustrate the interior and exterior configuration of the ceramic encasement 10. FIG. 2A shows the forward interior surface 54 against which antenna 14 is mounted. FIG. 2B shows the profile of the interior surface 54, conforming approximately to the profile of the exterior surface 56. FIGS. 2A, 2B and 2C also illustrate the configuration of the bottom edge 12 which rests upon the upper ledge of the urinal, with the strip of conductive material 11 interposed therebetween.

FIG. 3 is a sectional view of the capacitance control system module along the plane 3-3 of FIG. 1, showing the spatial relationships of the various antenna system components. It will be noted that the conductive strip 11, which conforms to the bottom edge 12 of ceramic encasement 10, is in electrical contact with the bottom portion 38 of mounting plate 30. Since the mounting plate 30 is at ground potential, a capacitance between antenna 14 to ground is formed, the encasement 10 acting as the dielectric. The result is a stabilized value of antenna capacitance to ground, which hitherto has been subject to substantial increases upon flushing of the urinal, such increases amounting to as much as one-half the signal, i.e., the increment of antenna capacitance to ground to which the system is designed to respond. Under such conditions, a person not within the utilization range of the urinal could supply the additional increment necessary to cause the system to respond as though a user were present within the utilization range, thereby causing unnecessary flushing. By intentionally forming a capacitance between the antenna 14 and the conductive strip 11, the strip being interposed between the bottom edge 12 and the water conduit 52, these spurious increases in capacitance to ground are eliminated. Shield 16 serves to interrupt the electric flux which, in the absence of shield 16, would exist between the antenna 14 and the grounded mounting plate 30. Wide variations in capacitance between shield 16 and the grounded mounting plate 30 have been found to have negligible effect on the sensitivity of the capacitance control circuit.

FIG. 4 schematically illustrates the basic capacitance responsive relaxation oscillator circuit in which the antenna system of the invention is adapted for use. This circuit is described in U.S. Pat. No. 3,199,033 and is just one of a number of circuits in which the invention may be employed. The output of the circuit is determined by the relative values of  $C_1$  and  $C_2$ , and  $R_2$  and  $R_3$ . When the values of these circuit components are chosen to provide the desired normal output, the output may then be altered by altering the value of  $C_1$ . It will be noted that the high sides of capacitors  $C_1$  and  $C_2$  are at the same voltage level, since both the plates "a" of  $C_1$  and  $C_2$  are ohmically connected to each other.

FIG. 5 illustrates the manner in which the various elements of the module form the capacitive elements of the oscillator circuit shown in FIG. 4, and in addition shows the relationship of the oscillator circuit to the remainder of the operative elements of the control module. The antenna 14 forms the plate "a" of  $C_1$  and the plate "a" of  $C_2$ . The shield 16 forms a part of the plate "b" of  $C_2$ . Hence, a first increment  $\Delta_1 C_2$  of  $C_2$  is formed between antenna 14 and shield 16. Since antenna 14 is electrically connected to the inner conductor 26 of coaxial cable 22, and the shield 16 is electrically connected to the outer conductor 24 of coaxial cable 22, a second increment  $\Delta_2 C_2$  of  $C_2$  is formed. Finally, for purposes of adjustment, a variable capacitance  $\Delta_3 C_2$  is connected between the inner and outer conductors 26 and 24 of coaxial cable 22. Thus, the

value of  $C_2$  is determined by the arithmetic sum of these three parallel-connected increments,  $\Delta_1 C_2$  plus  $\Delta_2 C_2$  plus  $\Delta_3 C_2$ . Antenna 14 also forms plate "a" of capacitance  $C_1$ , plate "b" of  $C_1$  being formed by a person moving into proximity with antenna 14 and grounded elements of the module. More specifically, there is a first increment  $\Delta_1 C_1$  of  $C_1$  formed between the antenna 14 and the body of a user. A second increment  $\Delta_2 C_1$  is formed between the antenna 14 and the conductive strip 11, the encasement interposed therebetween forming the dielectric. The introduction of any other significant capacitances between antenna 14 and ground prevented by the interposition of shield 16 between the antenna 14 and the grounded mounting plate 30. Thus, the two capacitances  $C_1$  and  $C_2$  are formed. The resistance elements  $R_1$ ,  $R_2$  and  $R_3$  of the oscillator circuit are discrete, lumped resistances. The pulses produced by the oscillator circuit are then amplified to a magnitude sufficient to actuate the switching circuitry which controls the energization and de-energization of a load, which, in the present application, comprises a flushing valve.

It will be noted that if the bottom portion 38 of the grounded conductive mounting plate 30 extends forwardly and laterally so that its periphery coincides with the outer portion of the periphery of edge 12 of encasement 10, the conductive strip 11 may be eliminated, since its function as explained herein will be carried out by the area of the bottom portion 38 in contact with edge 12. Alternatively, bottom portion 38 may be eliminated, since the conductive strip 11 will interrupt the electric flux which would form between antenna 14 and the water flowing through the lateral portion of conduit 52, while the shield 16 would interrupt the flux which would form between antenna 14 and the portion of the conduit carrying water forward from the input connection of the urinal. In such an embodiment, an electrical connection would have to be made between the conductive strip and ground, e.g., by a small vertical extension 13 of strip 11 which would contact the back portion 32 of grounded mounting plate 30.

The encasement 10 will usually be formed of a refractory material, but may be formed of any material having a dielectric constant substantially greater than that of air.

Referring to FIG. 6, this embodiment differs from that shown in FIG. 1 in that a conductive ring 15 including a tab portion 17 is disposed within the encasement 10 about the periphery of the antenna member 14. Also, a spring contact 19 extends upwardly from shield 16 to make electrical contact with tab portion 17 of connector element 15. The conductive strip 11 and the bottom portion 38 of the grounded conductive mounting plate 30 shown in FIG. 1 have been eliminated. The embodiments shown in FIGS. 1 and 6 are structurally identical otherwise.

FIG. 7 illustrates the manner in which the various elements of the module shown in FIG. 6 form the capacitive elements of the oscillator circuit shown in FIG. 4. The increments  $\Delta_1 C_2$ ,  $\Delta_2 C_2$  and  $\Delta_3 C_2$  are formed in the same manner as described in connection with FIG. 5. An additional increment of  $C_2$  is formed between the antenna 14 and the conductive ring 15, the encasement serving as a dielectric therebetween. Thus, the net value of  $C_2$  is the arithmetic sum of the four parallel-connected increments  $\Delta_1 C_2$ ,  $\Delta_2 C_2$ ,  $\Delta_3 C_2$  and  $\Delta_4 C_2$ . Any electric field which might be set up in the encasement 10 between grounded elements in the facility upon which the module is placed and the antenna member 14 is intercepted by conductive ring 15, which is closer to such elements than the antenna member 14. Thus, the need for increment  $\Delta_2 C_1$  in FIG. 5 is obviated, and the no-signal value of  $C_1$  is greatly reduced. Specifically, in the embodiment shown in FIG. 1, the no-signal value of  $C_1$  is between 15 and 17 picofarads, whereas in the embodiment shown in FIG. 6, this value is only between 4 to 5 picofarads. It has been found that the stability of the oscillator circuit shown schematically in FIG. 4 is increased as the no-signal value of  $C_1$  is decreased, i.e., the operation of this circuit is effected to a lesser degree by variations in the values of the other circuit elements. A better ratio of the signal capacitance to residual capacitance also results, and sensitivity is enhanced.

The conductive ring 15 is contoured to take the shape of inner surface of the encasement 10, and is spaced as closely as practical to the antenna member. Limitations are imposed upon this spacing by the hazard of arcing between antenna member 14 and conductive ring 15 across the inner surface of the encasement 10.

The capacitance to ground of  $C_{ab}$  (FIG. 4) has been found to have a far smaller effect on circuit operation than fluctuations of the capacitance to ground of  $C_{in}$ . Thus, it is also desirable to make the conductive ring 15 shown in FIGS. 6 and 7 as wide as practical so as to enhance its shielding capabilities.

The advantages of the present invention will be apparent to those skilled in the art, as well as changes which could be made in the foregoing embodiments without departing from the spirit and scope of the invention. Therefore, it should be understood that the present invention is not to be limited to the foregoing description of the specific embodiments thereof, but is to be determined by the spirit and scope of the accompanying claims.

What I claim is:

1. In a capacitance-responsive circuit operative to provide an output which varies in response to changes in detected capacitance, said circuit including first and second capacitances which have a common first plate, the improvement comprising: a modular antenna system for retrofitting existing facilities and comprising (1) electrically-conductive antenna means formed by said common first plate of said first and second capacitances, a second plate of said first capacitance being formed by an object to be detected, and (2) electrically-conductive shielding means forming a second plate of said second capacitance and shielding said antenna means from rearwardly-positioned grounded elements, said antenna means being substantially coextensive horizontally and vertically with said shielding means and being disposed between said shielding means and any object within the utilization range of said antenna system so as to prevent any substantial capacitive coupling between said shielding means and such object.

2. The antenna system according to claim 1, further comprising a coaxial cable having an inner conductor and an outer conductor, said inner conductor being electrically connected to said antenna means and said outer conductor being electrically connected to said shielding means, said coaxial cable forming an increment of said second capacitance and serving to connect said antenna means and said shielding means to the remainder of said capacitance-responsive circuit.

3. The antenna system described in claim 2, further comprising an adjustable capacitance electrically connected between said inner and outer conductors of said coaxial cable, thereby forming an increment of said second capacitance.

4. The antenna system described in claim 2, further comprising an encasement containing said capacitance-responsive circuit, and contoured to be installed adjacent to a sanitary facility to be retrofitted, said encasement being composed of a material having a dielectric constant substantially higher than that of air and having a conductive strip co-extensive with the surface of the encasement adjacent to the sanitary facility, said strip, said encasement and said antenna means forming an increment of said first capacitance.

5. The antenna system described in claim 4, further comprising a grounded conductive mounting member, said conductive strip being electrically connected to said mounting member for interposition between said surface of the encasement adjacent to the sanitary facility to be retrofitted and the adjacent channel of flow in the sanitary facility.

6. The antenna system described in claim 5, wherein:

1 said mounting member includes:

a. opposite side portions,

b. protrusions extending inwardly from the forward upper area of said side portions;

2 said shielding means is substantially L-shaped and comprises:

a. an insulating strip along the vertical and lower horizontal edges,

b. a pair of hook members engaging said protrusions, thereby suspending said shielding means between substantially the entire forward surface of said mounting member and the rear surface of said antenna means and electrically insulating said shielding means from said mounting member;

3 said encasement is contoured to abut the upper exterior surface of the sanitary facility to be retrofitted; and

4 said antenna means is mounted against the forward interior surface of said encasement.

7. The antenna system described in claim 2, further comprising a grounded conductive mounting member and an encasement covering said capacitance-responsive circuit and the load controlled thereby, and contoured for installation adjacent to a sanitary facility to be retrofitted, said encasement being composed of a material having a dielectric constant substantially higher than that of air and said mounting member having a bottom portion, the peripheral area of which is contoured for interposition between a surface of the sanitary facility to be retrofitted and the surface of the encasement adjacent to said surface of the sanitary facility, said antenna means, said encasement and said lower portion of said mounting member forming an increment of said first capacitance.

8. The antenna system described in claim 7, wherein:

1 said mounting member includes:

- a. opposite side portions,
- b. protrusions extending inwardly from the forward upper area of said side portions;

2 said shielding means is substantially L-shaped and comprises:

- a. an insulating strip along the vertical and lower horizontal edges,
- b. a pair of hook members engaging said protrusions, thereby suspending said shielding means between substantially the entire forward surface of said mounting member and the rear surface of said antenna means and electrically insulating said shielding means from

said mounting member;

3 said encasement is contoured to abut the upper exterior surface of the sanitary facility to be retrofitted; and

4 said antenna means is mounted against the forward interior surface of said encasement.

9. The antenna system according to claim 1, further comprising a conductive ring disposed about the periphery of said antenna means in proximity thereto to form a second plate of said second capacitance.

10. The antenna system according to claim 8, further comprising a grounded conductive member and an encasement covering said capacitance-responsive circuit and contoured for installation adjacent to a sanitary facility to be retrofitted, said encasement being composed of a material having a dielectric constant substantially higher than that of air, said antenna means and said conductive ring being disposed upon the forward inner surface of said encasement.

11. The antenna system described in claim 10, wherein:

1 said mounting member includes:

- a. opposite side portions,
- b. protrusions extending inwardly from the forward upper area of said side portions;

2 said shielding means is substantially L-shaped and comprises:

- a. an insulating strip along the vertical and lower horizontal edges,
- b. a pair of hook members engaging said protrusions, thereby suspending said shielding means between substantially the entire forward surface of said mounting member and the rear surface of said antenna means and electrically insulating said shielding means from said mounting member;

3 said encasement is contoured to abut the upper exterior surface of the sanitary facility; and

4 said antenna means is mounted against the forward interior surface of said encasement.

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