Jan. 5, 1971 N. A. FORBES 3,551,919

ANTENNA SYSTEM FOR PROXIMITY CONTROL

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FIG. 2

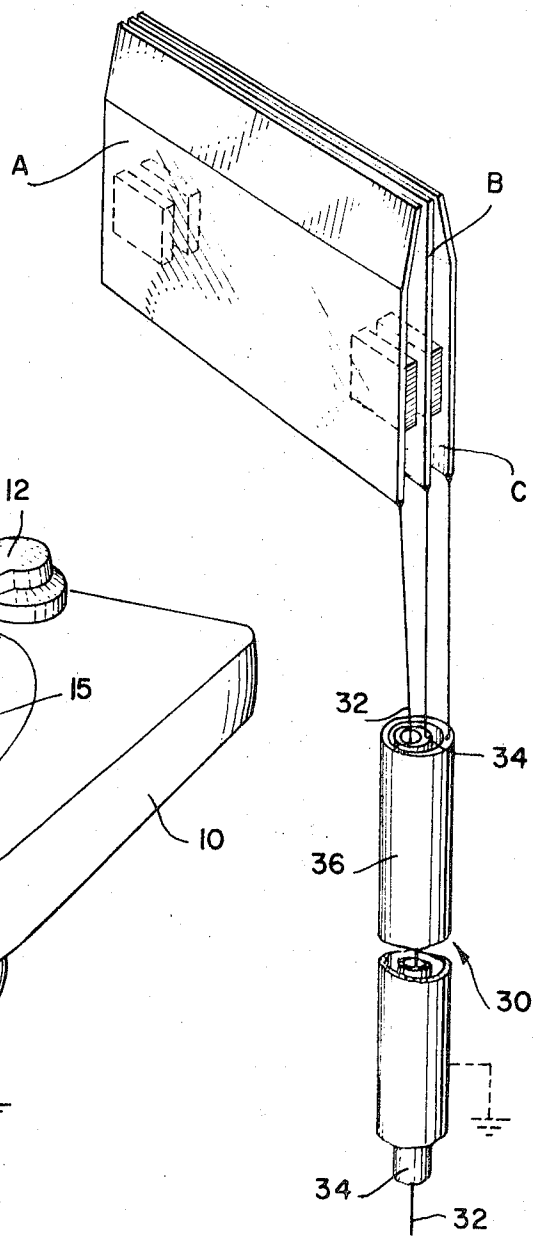
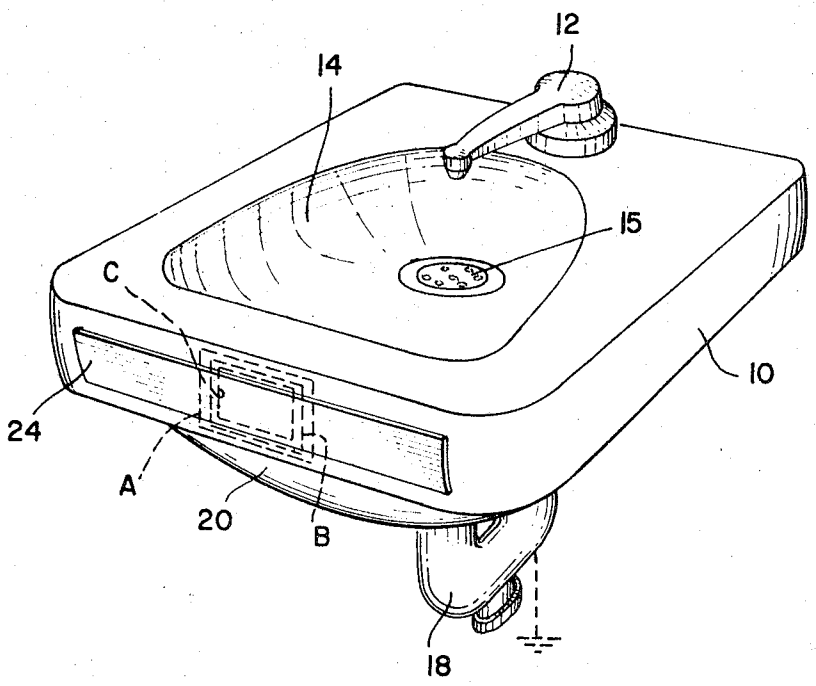


FIG. 1



INVENTOR.
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ANTENNA SYSTEM FOR PROXIMITY CONTROL

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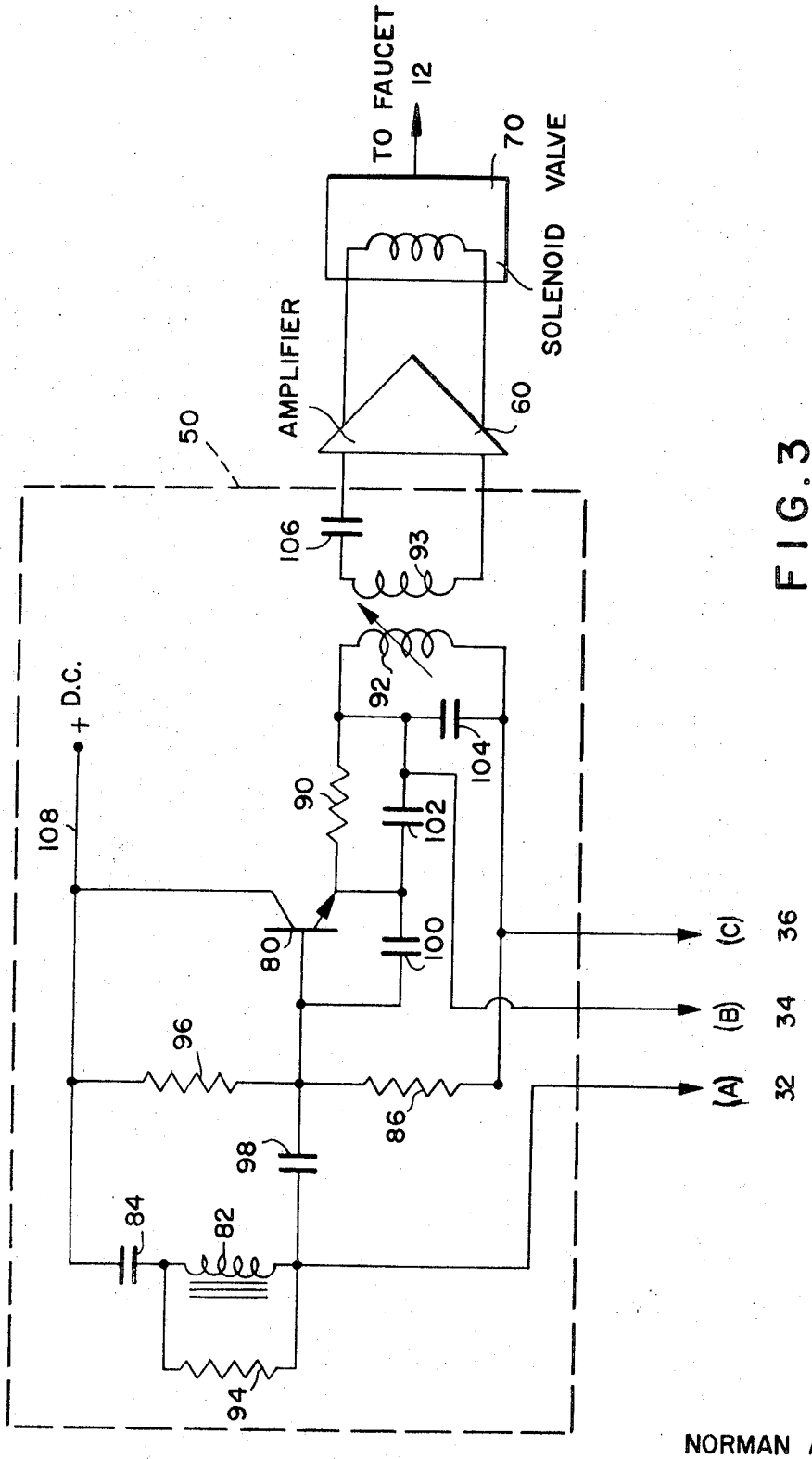

FIG. 3

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FIG. 4

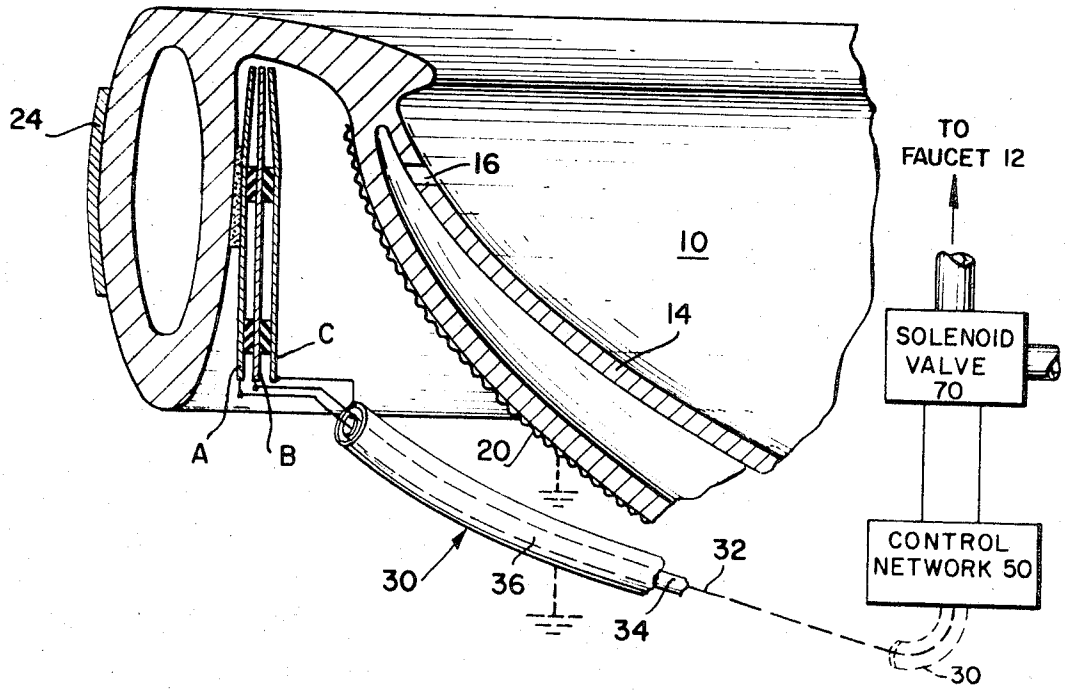
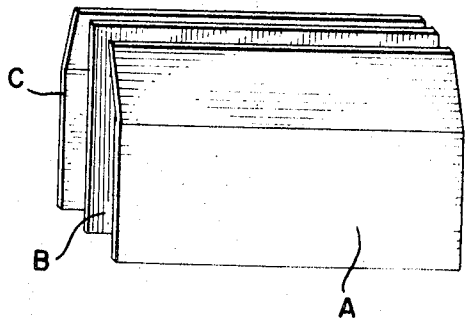


FIG. 6



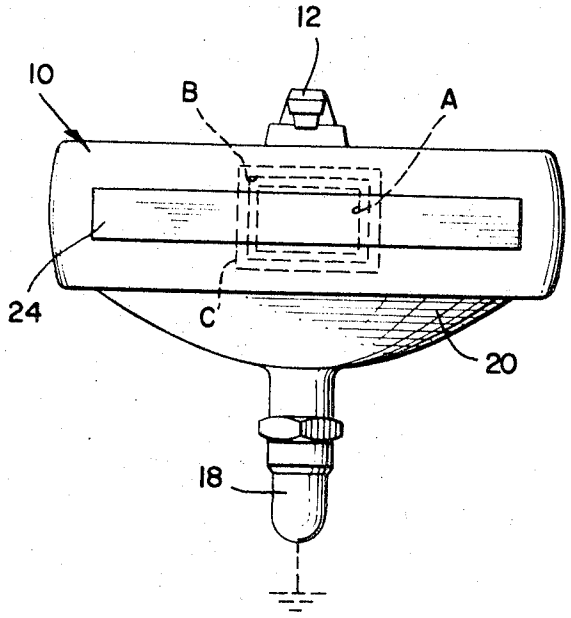


FIG. 5

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3,551,919

ANTENNA SYSTEM FOR PROXIMITY CONTROL

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Int. Cl. A47k 1/04
U.S. Cl. 4—166 15 Claims

ABSTRACT OF THE DISCLOSURE

Covers to plumbing and other systems which respond, for example, to the approach or withdrawal of a user. The arrangement includes a primary antenna structure which changes in electrical capacitance in response to the approach or withdrawal of the user, a control circuit connected to the antenna structure, and a translating device, such as a valve which is to be operated or released. The arrangement includes a secondary antenna to render the primary antenna structure more sensitive. A coaxial cable system interconnects the primary antenna structure to the control circuit. When the arrangement is applied to a plumbing fixture, a grounded shield is applied to the plumbing fixture.

This invention relates to what are known as proximity control systems and apparatus for use, for example, with a lavatory or other plumbing equipment for the control of the flow of water from such equipment. More specifically, this invention relates to improved proximity control systems and apparatus utilizing a capacity-sensing plate or plates, hereinafter generally referred to as an antenna or an antenna structure or system, for sensing the presence of a user of such equipment, said systems and apparatus being so arranged as to permit the user to initiate the operation of such equipment, and to terminate the operation of such equipment.

Proximity control systems and apparatus have heretofore been proposed which embodied an antenna system connected or otherwise coupled to a control apparatus which in turn was connected or coupled to a solenoid valve unit which may be turned on and off to control the flow of water or other fluid in a plumbing fixture. In such a system the antenna arrangement may, for example, be positioned physically behind or on the underside of the plumbing fixture, and the control apparatus may also be positioned in a similar inconspicuous location, if desired, or in any other location, preferably one closely adjacent to the plumbing fixture. In such an arrangement the antenna responds to the approach of the user to develop, for example, a change in capacitance which would in turn activate the control system so that the solenoid equipment would be likewise operated to initiate a flow of liquid.

Such a proximity control system, however, can be readily affected by a number of variable conditions which may interfere with the proper operation of the mechanism. For example, if the plumbing fixture is a lavatory, the basin may have a full load of liquid, or it may be only partially loaded with liquid, or perhaps even it may be empty. In such a proximity control system, the effect of liquid in the basin is usually to add capacitance between the antenna to ground, because the liquid itself is normally grounded by the drain. Such added capacitance due to liquid in the basin tends to make the control system more responsive, since, with the added capacitance present, the user needs to add less capacitance than is normally required to turn on the flow of liquid. In extreme cases, the liquid can be turned on, and the liquid will remain turned on by the capacitance due to the presence of liquid previously poured into the basin. Alternatively, if

the control is made less responsive so that previously supplied liquid in the basin will not turn on the flow of liquid when the basin is full, then the system will be inoperative when the basin is dry. Therefore such conditions change the sensitivity of the antenna structure or perhaps render it inoperative in many cases.

Furthermore, the lavatory, if it includes vitreous china, may introduce an abnormal thickness of dielectric between the body of the user and the antenna and therefore seriously reduce the responsiveness of the equipment. Still furthermore, the user may not move his body close enough to the front of the lavatory, whereupon the equipment may not respond properly, or perhaps remain inoperative, due to the remoteness of the user's body. These are some of the more important other conditions that materially change the operative characteristics of previously proposed proximity systems and have therefore inhibited their commercial use.

Still another difficulty heretofore encountered with proximity control systems for use in plumbing fixtures is that the electrical conductor connecting the antenna to the control circuit was sensitive to and affected by water in the basin and to other grounded objects because it could easily have appreciable capacitance to these objects. Therefore, to minimize the effects of these unwanted stray and interfering capacitances and other reactances, it was usually necessary to route the antenna conductor, by a short direct route, away from the basin and from grounded objects. Unfortunately, the conductor in this position tended to interfere with normal cleaning operations, and was vulnerable to attack by vandals.

It is therefore one of the principal objects of this invention to increase the responsiveness of so-called proximity control systems and apparatus by having the systems and apparatus respond, for example, to the intended users but to remain substantially non-responsive to other personnel and to stray reactive effects.

It is another object of this invention to provide a proximity control system and apparatus for a plumbing fixture which will be substantially independent of the amount of fluid, if any, that may be present in a plumbing fixture as, for example, a wash basin.

It is still a further object of this invention to provide a proximity control system and apparatus which will permit the antenna and the rest of the control system to be connected together by a coaxial control system so as to shield the conductor or conductors interconnecting the antenna structure with the control system. Such a coaxial system will also serve to diminish the extraneous electrostatic charges that may become superimposed upon the antenna structure and adversely affect the operation of the control system.

In order to carry out the features and general objects of this invention, a single conductive coating has been conceived and devised to be applied, for example, to the underside of the bowl of a basin or other plumbing fixture and the conductive undercoating is to be connected to the normally grounded drain pipe. Such a grounded conductive coating has the direct effect of substantially reducing, if not completely eliminating, the variable effects upon the antenna system brought about by the presence of water in the plumbing fixture whatever its level and even by the absence of water in the plumbing fixture.

According to this invention, a so-called secondary antenna, preferably in the form of a metal plate or other electrically conductive film, may be affixed to the front edge of a plumbing fixture such as a basin. This secondary antenna is coupled capacitively through the vitreous china to the primary antenna, and is otherwise unconnected to any part of the proximity control system and apparatus. The secondary antenna will have the effect of rendering

the primary antenna structure more responsive to the presence of a user, and hence the control will be operative at all times to respond unfailingly to the approach of the user within a predetermined distance of the plumbing fixture, such as 7 inches.

According to this invention, the antenna structure which, as already suggested, may be physically positioned on the underside of the bowl or other plumbing fixture, may be built in the form of, for example, three plates or other conductive films or media, and the plates may be spaced and insulated from each other and arranged so as to be coupled to the control equipment. Such an antenna structure may be connected to the control equipment by means of a coaxial conductor system which includes a central conductor and two (or more) coaxial sheaths which are insulated from each other and from the central conductor. By this coaxial arrangement, the conductor connected between the antenna and the rest of the control system will be shielded from capacitive coupling to grounded objects and to water in the basin, in the case of a lavatory, and said conductor will be protected from vandalism and can be routed near grounded objects if desired.

These objects and the general principles and features of this invention will be better and more completely understood from the more detailed description hereinafter following when read in connection with the accompanying drawing in which:

FIG. 1 illustrates schematically a basin or like plumbing fixture showing some of the apparatus that may be employed in connection with a plumbing fixture, for example, in the practice of this invention;

FIG. 2 schematically illustrates the interconnection of the primary antenna system of this invention with a coaxial cable system;

FIG. 3 illustrates schematically the circuit arrangement of a form of control equipment for interconnecting the conductors of the coaxial cable system of this invention with other equipment employed for starting and stopping a device such, for example, as a solenoid valve which operates a faucet;

FIG. 4 illustrates a part of the apparatus of FIG. 1 in more detail;

FIG. 5 illustrates a front view of a plumbing fixture in the form of a wash basin for use in this invention; and

FIG. 6 illustrates a perspective view of a form of the antenna structure arrangement.

Like reference characters will be used throughout the drawing and description to designate like parts.

Referring to the drawing, and especially to FIG. 1, there is shown a plumbing fixture **10** in the form of a lavatory having a spout **12** mounted over a basin **14**. A drain **15** is provided at the lowest point within the basin **14**, preferably beneath the liquid discharge opening of the faucet **12**. Secured behind the basin **14**, but along or adjacent to its inner front wall, there is a primary antenna structure consisting of a primary antenna A and shields B and C which are insulated from each other by air or other dielectric. Shield C is connected to ground and may be considered as a primary shield and connected electrically to the drain pipe **18** which is normally grounded and discharges fluid into the sewer system. The underside of the lavatory **10** has applied thereto a conductive coating, designated **20**, which may be of any desired composition and arranged by coloration or otherwise to harmonize with the coloration of the basin **10**. The undercoating **20** is electrically in contact with the drain **18** and therefore also grounded. The secondary antenna **24** may be applied or otherwise affixed to the front outer edge of the basin **10**. The secondary antenna **24** is preferably in the form of a metal plate or other electrically conductive film and may be made of decorative or transparent material and it is not connected to any part of the equipment but it is separated physically from the primary antenna structure A, B, C by the china or other dielectric material of which

the basin **10** is composed. The components A, B and C of the antenna system may be metallic plates of the same or different lengths and widths and they are coordinated so as to constitute a conjoint structure employed primarily to sense the presence or absence of an individual or user. If desired, a different number of such components may be coordinated into the antenna structure.

Referring more particularly to FIG. 2, the primary antenna system A, B, C is connected to a coaxial cable system **30** which is shown as including a central conductor **32**, a first or inner concentric sheath **34**, and a second or outer concentric sheath **36** which is preferably grounded. The central conductor **32** is insulated from the first or inner sheath **34** by air or other dielectric, and the first sheath **34** is insulated from the second or outer sheath **36** by air or other dielectric. If the antenna structure included additional plate components, then the coaxial cable system might include additional sheaths. The outermost sheath is grounded.

FIG. 3 schematically illustrates the interconnection between the components **32**, **34**, and **36** of the coaxial cable system **30** and a part of the rest of the system and apparatus. The control apparatus **50**, which is shown bounded by dotted lines, connects the components of the coaxial cable system to, for example, a unidirectional amplifier **60** which in turn is connected to a solenoid valve **70** which, as will be apparent, will control the operation of the faucet **12** (see FIG. 1).

The control apparatus of FIG. 3 includes an electric oscillator which may be of any well known form and may be designed to generate electromagnetic waves of any desired frequency, such as, for example, 8 mHz. This electric wave oscillator includes a transistor **80** and its input circuit includes a series path provided by conductor A, winding **82**, capacitor **84**, the collector and base of transistor **80**, resistor **86** and shield C of the antenna structure which is connected to the grounded outer sheath **36** of the coaxial cable system **30**. The output circuit of the oscillator includes the emitter of the transistor **80**, resistor **90**, and coil **92** which is also connected to shield C and the grounded outer sheath **36**. The coil **82** is shunted by resistor **94**. The collector of transistor **80** is connected to the base of transistor **80** by a resistor **96**. The base of transistor **80** is connected to the conductor A by a capacitor **98**. The emitter and base of the transistor **80** are connected by a capacitor **100**. A capacitor **102** bridges resistor **90**. The coil **92** is bridged by a capacitor **104** which is used along with coil **93** principally for tuning or adjusting the frequency of the oscillations generated by the oscillator. The terminal common to capacitors **102** and **104** is connected to the secondary shield B via inner sheath **34**. The capacitor **106** feeds the generated oscillations to the amplifier **60** which may be of any well known form. A source of D.C. voltage is supplied to the conductor **108**.

The oscillator illustrated in FIG. 3 may be considered to be a modified Colpitts oscillator, arranged so that the collector terminal of the transistor **80** is connected to ground for high frequencies. The network between collector and base includes capacitor **84**, inductor **82**, resistor **94** and the antenna-to-ground capacitance. In practical use, the operating frequency is adjusted so that the latter network is slightly inductive, the usual condition for oscillation in a Colpitts oscillator as is well known to the art. A slight increase in the antenna-to-groud capacitance tends to make the latter network capacitive and, at a predetermined level of antenna capacitance, the oscillator stops oscillating. The amplifier **60** senses the oscillator output, and the amplifier output is used to switch the solenoid valve **70** on and off when the oscillator stops and starts.

The essential ports of the foregoing circuit that enable a three-element coupling system to be used are capacitance **104** and the series combination of capacitances **98**, **100**, and **102**. It has been observed that, although the antenna

cannot tolerate much capacitance directly from antenna-to-ground, it can tolerate considerable added capacitance from antenna to the junction of capacitor **102** and capacitor **104**, and the system can likewise tolerate considerable added capacitance across capacitor **104**. In fact, to a large extent the effect of the added capacitances discussed above can be largely compensated by removing capacitance within the circuit itself. Therefore, a capacitive cable assembly which adds capacitance in the manner discussed above can be used to couple the antenna to the rest of the control circuit.

FIG. 4 schematically illustrates, in section, a segment of the bowl **10**. Here the primary antenna structure A, B, C is shown in a side view and it is positioned and affixed in any well known manner to the front inner underside of the outer rim of the basin **10**. The antenna structure A, B, C is shown connected to the coaxial cable system **30**. The secondary antenna **24** is shown attached to the front outer edge of the basin **10**. It will be observed that the secondary antenna **24** is spaced and insulated from the antenna structure A, B, C by portions of the dielectric material of which the basin **10** is composed.

It will be apparent that in the absence of the bottom coating **20**, the secondary antenna **24**, and the coaxial cable system **30**, the proximity control system would be subject to numerous adverse and detrimental effects which impair, if not completely render inoperative, the control system. For example, the presence of water within the basin **10** would change the electrostatic flux and other characteristics and thereby materially affect the operation of the system. A fully loaded basin would have a reactive effect which produces a different signal from, for example, a basin which is only half loaded or has no water whatever in it. Also, without the secondary antenna **24**, the operativeness of the system would be changed in important respects if the user were spaced from the basin by, for example, 7 inches. Without such antenna **24**, the signal transmitted to the solenoid valve **70** might then be very small if not completely negligible, and, on the other hand, if the user pressed against the front wall of the basin, then a very different signal would be developed.

Furthermore, the antenna system might be connected to the control apparatus by a loosely hung or dangling wire or wires which are not only unsightly, but would be subject to electrostatic and electromagnetic changes due to the physical positions of other apparatus in the bathroom or kitchen or due to mishandling by personnel, so as to seriously interfere with the operation of the equipment. All of these adverse affects are greatly improved by each of the components **20**, **24**, and **30** when considered separately and the overall system is further improved by any combination of these components or by the addition of all the components. The addition of all the components would undoubtedly render the system relatively free from disturbances and experiences heretofore encountered in proposed proximity control systems.

The three components A (**36**), B (**32**) and C (**34**) of the antenna structure are spaced and insulated from each other either by layers of insulation of any well known form or by lumped insulation positioned at selected points between these components. Together they form a unitary arrangement which combines electrically with the secondary antenna **24** and the grounded film **20** to virtually eliminate the undesirable effects which were previously attributed to the presence or absence of fluid in the basin **10** or to the relative physical position of the user with respect to the front of the basin **10**.

It will be apparent that the oscillator may be normally generating oscillations which are changed in frequency or quenched in response to the arrival of a user or, if desired, the oscillator may be set into operation at its assigned frequency only upon the arrival of the user.

It will be understood that, according to this invention, the arrangement set forth above is caused to operate in response to the approach of the user within specified spacial distances and to release upon the withdrawal of the user beyond the specified spacial distances.

It will be understood that the construction of the electric oscillator shown in FIG. 3 is given only for illustration and that any other electric oscillator may be substituted therefor. Furthermore, the oscillator may be arranged to generate oscillations of any desired or preferred frequency. The oscillator may also generate oscillations of a relative low frequency which may be within or slightly above the audio range and such oscillations may be employed for the same purpose. The employment of the coaxial cable system together with the other features above referred to serve to render the proximity system operative even with a low power output from the electric wave oscillator. The lower the power output, the lower will be the effects upon other electric oscillatory and transmission equipments which are within range of the proximity control apparatus.

While the invention has been shown and described with reference to a plumbing fixture such as a wash basin, it is equally applicable to other equipments whether or not they are plumbing fixtures. For example, the equipments of this invention are indeed applicable to burglar or other alarm systems, for example, where the features of this invention would serve to render the alarm system continuously operative and more sensitive to detect the presence of a person or condition. As a further example, the coaxial cable system may be employed for connection to any transmission system which may embody, for example, an antenna which is coupled to a control or resonant circuit by means of a reactive component, and which control or resonant circuit has another reactive component connected from the antenna coupling component to ground. This permits the connection or application to the transmission circuit of supplemental or parallel connections to the terminals of the coaxial cable system so as to shunt the transmission system, or parts thereof, to the coaxial cable system to protect the antenna from unwanted capacitance to ground.

While this invention has been shown and described in certain particular arrangements for illustrative purposes, it will be understood that the equipments, features, and general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. Apparatus including a plumbing fixture and a translating device therefor, said apparatus controlling the operation of said translating device, said apparatus comprising an antenna structure secured to said plumbing fixture and being responsive to the proximity of a human body, control means coupling said antenna structure to said translating device so that said control means may normally respond to electrical changes in said antenna structure to operate said translating device, an isolated metallic element secured to said plumbing fixture and spaced from and unconnected to said antenna structure or to any other metallic structure for increasing the sensitivity of said antenna structure to the proximity of the human body and for improving the operation of said translating device, and additional means in the form of a conductor applied to said plumbing fixture for rendering said control means substantially ineffective with respect to water within said plumbing fixture.

2. Apparatus according to claim **1**, in which said translating device is a faucet.

3. Apparatus according to claim **1**, in which said translating device is a signal responsive device.

4. Apparatus according to claim **1**, in which said antenna structure and said control means include a central conductor and concentrically positioned conductors acting as shields interconnecting said antenna structure and said control means.

5. Apparatus according to claim 1, in which the control means generates an alternating voltage and includes means responsive to predetermined changes in the antenna structure to operate said translating device.

6. Apparatus according to claim 5, in which the control means includes means such that the magnitude of the alternating voltage responds to changes in the capacitance from the antenna structure to ground to operate said translating device.

7. Apparatus according to claim 5, in which the control means employs a reactive coupling means between the alternating-voltage generator and the translating device as well as reactive frequency-determining means across the output of the alternating-voltage generator, said reactive coupling including a first reactance element between the central conductor and the inner concentric shield, and said reactive frequency-determining means including a second reactance element connected between the inner concentric shield and the outer concentric shield.

8. Apparatus including a plumbing fixture having a faucet for controlling the opening and closing of the faucet, comprising an antenna structure which electrically responds to the approach of a user within a predetermined distance of said fixture, means controlled by said antenna structure to open said faucet and then to close said faucet, and additional means conductively applied to said fixture for rendering said control means substantially ineffective with respect to water within said plumbing fixture.

9. Apparatus according to claim 8 in which said additional means comprises a grounded conductive element affixed to said plumbing fixture.

10. Apparatus according to claim 8 in which said controlled means includes a central conductor and concentrically positioned conductors acting as shields and connected to said antenna structure.

11. Apparatus according to claim 8 in which said means controlled by said antenna structure includes a generator of alternating voltage the magnitude of which is responsive to the approach or withdrawal of a user.

12. The combination of a wash basin having a faucet and a solenoid valve controlling the faucet, a control network for operating and releasing said solenoid valve, a primary antenna network secured to said wash basin and responsive to the approach of user within a predetermined distance of said basin for activating said control network in order to operate said solenoid valve, and a secondary antenna secured to the front portion of said wash basin and spaced from and in front of said primary antenna network to substantially render said primary antenna more sensitive to the presence of a user.

13. The combination of claim 12, which includes a grounded metallic shield applied between said wash basin and said primary antenna network.

14. The combination of claim 12 in which said primary antenna network includes a central conductor having surrounding concentric conductors acting as shields coupling said primary antenna network to said control network.

15. The combination of claim 12 in which said control network includes an alternating voltage generator and means which are responsive to predetermined changes in the output of said generator for operating and releasing said valve.

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G. H. KRIZMANICH, Assistant Examiner

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