

April 29, 1958

H. SNYDER

2,832,950

ALARM SYSTEM

Filed Aug. 2, 1956

2 Sheets-Sheet 1

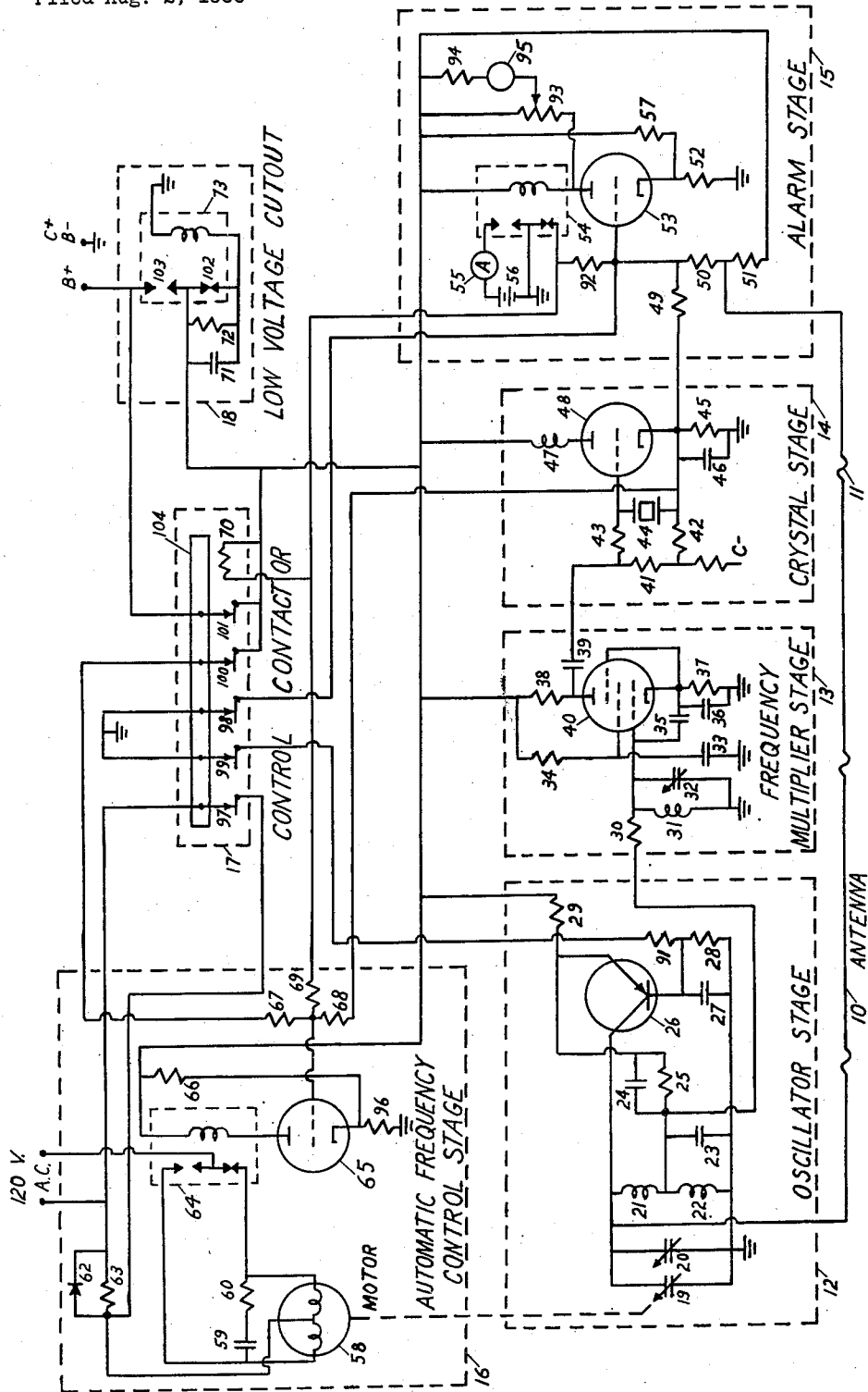


FIG. 1

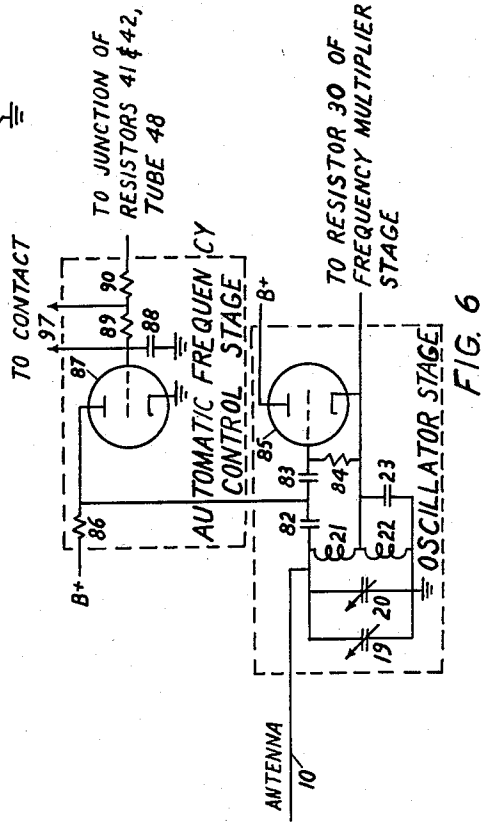
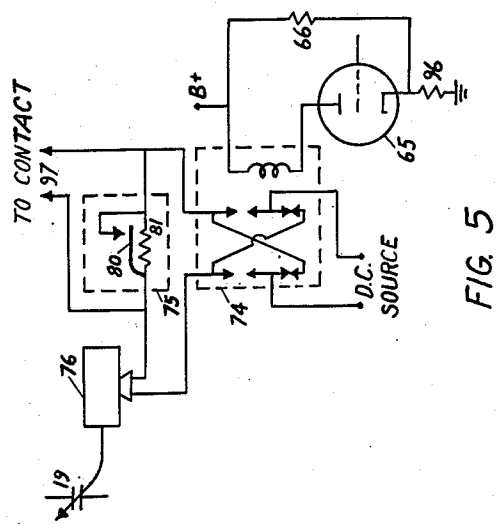
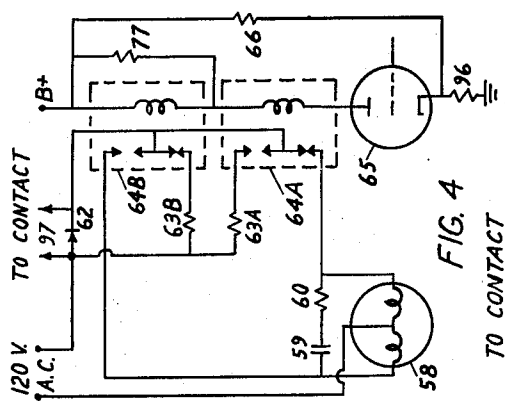
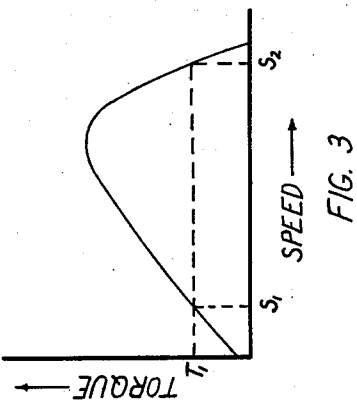
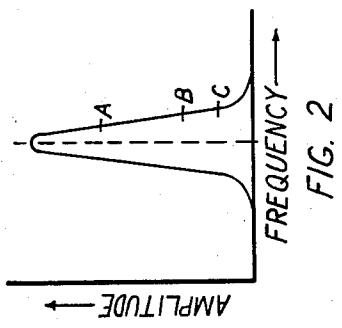
April 29, 1958

H. SNYDER
ALARM SYSTEM

2,832,950

Filed Aug. 2, 1956

2 Sheets-Sheet 2



1

2,832,950

ALARM SYSTEM

Herman Snyder, Paterson, N. J.

Application August 2, 1956, Serial No. 601,841

16 Claims. (Cl. 340—258)

The invention relates to alarm systems for use against intrusion and fire.

This invention is of the type which utilizes the change in the capacitance of an antenna, due to the approach of an intruder, to protect the doors, windows, walls, ceilings, and floors of the premises. This antenna may, of course, also be utilized to protect areas if desired. Furthermore, by the insertion in this antenna of one or more suitable links of fusible metal, or of thermostatic elements, the invention also provides an alarm whenever the temperature in the premises rises more than a predetermined amount. In this fashion the same antenna utilized for protection against intrusion also provides notification against fire.

Previous alarm systems of the capacitance type have encountered certain problems in their operation. Among these problems have been the following: (1) Existence of capacitance changes due to causes other than the approach of an intruder; (2) complicated testing circuits to determine the condition or operativeness of the system; (3) requirements for personnel for adjustment and monitoring of the system; (4) difficulties in operating the system directly from the alternating-current line, battery operation of the system generally having been necessary. Simple and satisfactory solutions of these problems will provide equipment of enhanced utility and application.

The principle object of this invention, therefore, is to provide an improved alarm system.

Another object of the invention is to provide an improved alarm system of the capacitance type.

Another object of this invention is to provide a capacity alarm system which will automatically compensate for capacity variations due to environmental or equipment changes.

Still another object of this invention is to provide a capacity alarm system which will at all times automatically indicate its state of operativeness.

A still further object of the invention is to provide a capacity alarm system requiring no monitoring and adjustment by the user.

Another object of the invention is to provide an alarm system which, with no appreciable additional equipment, provides protection against both intrusion and fire.

Other objects and advantages, as well as a fuller understanding of the invention, may be ascertained by referring to the following description and claims, taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a circuit diagram of one form of the invention.

Fig. 2 shows the output response of the crystal stage of Fig. 1 as the frequency of the input voltage thereto is varied.

Fig. 3 shows a generalized torque vs. speed characteristic of an induction or magnetic rotating-field type motor.

Fig. 4 illustrates an alternative frequency control stage for Fig. 1.

Fig. 5 shows a method of obtaining extremely slow motor speeds by electrical means.

Fig. 6 exhibits a non-mechanical method of frequency control.

2

Referring to Fig. 1, it can be seen that this particular form of the invention is comprised basically of the following:

(1) An antenna 10, which is normally placed in proximity to windows, doors, and other openings; and which may also be placed, if desired, on floors, walls, and ceilings, and around areas. The approach of an intruder to within a predetermined distance of this antenna will change its capacitance to ground sufficiently to activate the alarm.

(2) One or more circuit-opening means 11, responsive to temperature, such as a fusible link or thermostatic switch, inserted in the antenna circuit. The rise of temperature in the premises to a predetermined value will melt the fusible link, or open the thermostatic switch, thus again activating the alarm.

(3) An oscillator stage 12, to which the antenna 10 is connected, the frequency of said stage being responsive to changes in antenna capacitance.

(4) A frequency multiplier stage 13, which provides a multiple of the oscillator frequency for application to the crystal stage 14.

(5) A crystal stage 14, which provides a voltage the value of which is determined by the output of the multiplier stage 13, which in turn is determined by the frequency of oscillator 12.

(6) An alarm stage 15, which is activated when the output of the crystal stage is sufficiently greater or less than a set amount; or which is activated when the antenna circuit is opened, such as by a thermostatic switch.

(7) An automatic frequency control stage 16, controlled, when the equipment is first put on, by control contactor 17, to move the frequency of the oscillator stage 12 to its on-guard value; and to respond relatively slowly, when the proper on-guard operating frequency has been achieved, to the output of the crystal stage 14 in such fashion as to maintain said operating frequency. The term "on-guard," as applied to the equipment, is meant in this specification to designate an operative equipment in alert condition ready to respond to possible intrusion.

(8) A control contactor 17, to program various operations in proper sequence. Most of the programming functions of this device occur during a relatively short interval of time preceding the attainment of normal on-guard operation of the system. This interval will hereafter be referred to in this specification as the initial adjustment period.

(9) A low voltage cutout 18, which deactivates the system to prevent false alarms when the line voltage is momentarily interrupted, or is otherwise improper.

Referring in more detail to antenna 10, it will be noted that this element connects both to oscillator stage 12 and to a point in alarm stage 15 between resistors 50 and 51. Both of these latter resistors are of high value, and therefore connection to this point has negligible effect on oscillator stage 12. However, for direct current, the junction of these resistors is maintained substantially at ground potential, the ground path occurring through coils 21 and 22. If a fire occurs, the temperature will rise, and 11 (being a fusible link, a thermostatic switch, or equivalent) will open the antenna circuit. The junction between resistors 50 and 51 will no longer be maintained at ground potential, and the potential on the grid of alarm tube 53, which is normally near cut off voltage with respect to the cathode, will become positive because of B+ acting through resistors 50 and 51. The tube will therefore draw sufficient current to activate relay 54, and alarm 55 will consequently sound off.

It should be noted that to secure both fire and intrusion detection, connection of the antenna need be made only to the oscillator stage, the approach of an intruder in-

creasing the capacitance effective at the oscillator, and opening of the antenna by fire or otherwise causing a decrease of capacitance. These effects could be utilized to provide alarms. However, when the equipment is not active, such as when the premises are in use, a section of the antenna may be cut out by a resourceful burglar. The equipment, when later activated, will compensate for the shorter antenna, and be effective only over the shorter length. Consequently, as a precautionary measure against such possible action by an intruder, the preferred connection for the antenna is as shown in Fig. 1, in which a cut or broken antenna will become immediately evident on activation of the equipment, by the sounding of the alarm.

Though a single wire is shown for the antenna, the return circuit exists in the ground or objects connected thereto. If desired, a second wire spaced a suitable distance from the antenna wire and connected to the opposite side of the oscillator tank circuit may be used as the ground, with an increase of sensitivity of the system. In any case, the term "ground" will be used in this specification to designate the return circuit no matter in what form it may be utilized.

The oscillator stage 12, to the tank circuit of which the antenna 10 is connected, is a Hartley type circuit employing in this particular application a transistor 26, though a radio tube could have been employed, if desired. (For example, see Fig. 6.) The voltage developed across resistor 25 which is in series with voltage-dropping resistor 29, provides the operating potential for the oscillator. Condenser 24 is an R. F. bypass. The fundamental frequency of operation is determined by the capacitance of the antenna circuit and by the LC network comprised of coils 21 and 22 in series, across which are connected variable condensers 19 and 20 in parallel, of which condenser 19 is driven by motor 58. Resistor 28 is a current limiting element to, and condenser 27 is a bypass for, the transistor. The function of resistor 91 will be explained in connection with the operation of the control contactor 17.

This Hartley-type oscillator has been modified in a very important particular in order to secure an output extraordinarily rich in harmonics for application to the frequency multiplier stage 13. It will be noted that the coil for the oscillator is divided into two parts, sections 21 and 22, in order to secure a coefficient of coupling between them of considerably less than unity. Furthermore, coil 22 is tuned by condenser 23, tuning being such as to accentuate the desired harmonic across this coil. Thus, by optimizing both coupling and tuning for maximum harmonic output, it becomes possible to do in one stage what can normally be accomplished only with a plurality of stages, namely the production of voltages of relatively large value at high harmonics of the fundamental. It should be noted that the distributed capacitance inherent in the coil itself may many times be sufficient to provide substantial output at the desired harmonic. It should also be noted that if the mutual coupling between coils 21 and 22 becomes too great, harmonic generation of the type described cannot be maintained, the voltage between their junction and ground becoming substantially the same in form as cross condenser 20, and being substantially sinusoidal. On the other hand, if the coupling becomes too loose, insufficient energy may be fed back to sustain oscillation.

The harmonic laden output available at the junction of coil 21 and 22 is applied to the frequency multiplier stage 13 through resistor 30. Coil 31 and condenser 32 are tuned to accentuate the desired harmonic, and to attenuate the fundamental frequency from the oscillator stage. The harmonic output of this circuit is applied to the grid of tube 40, which in this particular stage is shown as a pentode.

The frequency multiplier stage 13 operates as a regenerative amplifier of high stability, so that the effective Q

of the stage has been greatly increased. As a consequence, the magnitude and quality of the output has been appreciably improved.

The harmonic output of stage 13, appearing across load resistor 38 is applied through plate-blocking capacitor 39, and through resistor 43 to crystal 44 of crystal stage 14. The crystal has been selected to resonate at the frequency of the desired harmonic output. The crystal voltage is applied to the grid of tube 48, which is maintained with no applied signal at a cut-off condition by the voltage drop across resistor 42 due to C—. Resistor 41 is effectively a grid leak for tube 48. When crystal output is present, tube 48 draws current, and a rise in voltage appears across resistor 45. In view of condenser 46, the voltage across output resistor 45 is effectively free of R. F. If the frequency of the oscillator is varied, the voltage output of resistor 45 of the crystal stage is found to be a function of the frequency as shown in Figure 2. This stage effectively is utilized as a discriminator, providing a more or less linear relationship over the right and left-hand slopes of the curve respectively. The use of a crystal for discriminator operation constitutes one method. However, other sensitive types of discriminators exist and could have been utilized if desired. Normally, in Figure 2, the operating point is maintained within a small frequency range at point B on the curve, circuitry, to be described later, acting at a very slow rate to maintain the operating or on-guard frequency within this range. If an intruder should approach the antenna, the capacitance across the tank of oscillator stage 12 will increase, the frequency will decrease, and the voltage across resistor 45 will rise above point A on the curve of Figure 2. This value of voltage is sufficient to operate alarm stage 15. If, however, a fault should develop in the equipment, or antenna capacitance to ground should be reduced by external action such as removal of a nearby object, and the voltage across resistor 45 falls below point C on the curve, the alarm stage will also be activated. How the alarm stage accomplishes these functions will be described next.

It will be noted in Fig. 2 that the right hand slope of the curve is being utilized in the operation of the alarm system. This is not a prerequisite for the successful operation of the system. The left-hand slope of the curve can also be utilized if desired; however the programming of operations and other circuitry would then require some modification for satisfactory functioning of the system.

The output of resistor 45 is fed through isolating resistor 49 to the grid of tube 53 in the alarm stage 15. Tube 53 is biased beyond cutoff by resistors 52 and 57. In the plate circuit of this tube is the coil of alarm relay 54, which is activated only when the voltage from the crystal stage rises to value A of Figure 2, this value being sufficient to override the bias of tube 53 and cause sufficient current to flow to operate relay 54. When the voltage is at value B (see Figure 2), insufficient current flows to activate the relay; however it is enough to cause an appreciable voltage drop across the plate load of tube 53. The neon lamp 95, together with current limiting resistor 94, is tapped across such proportion of the plate load voltage by means of potentiometer 93, that the neon lamp goes out when the voltage from the crystal stage drops under value C in Figure 2. Thus, if for any reason, the output of the alarm stage should drop below a value corresponding to the value C, the neon lamp will indicate malfunctioning of the equipment by failing to light.

It should be pointed out that, if desired, an aural indication of equipment failure or antenna capacitance reduction can also be secured by the utilization of an additional relay in the plate circuit, this latter relay being adjusted to be of such effective sensitivity as to be deactivated whenever the plate current in tube 53 drops below the value corresponding to point C on the curve; and thereby closing a circuit to an alarm, such as a bell.

To maintain the alarm in operation after the intruder

5

has withdrawn from the vicinity of the antenna, a contact on the alarm relay 54 ungrounds resistor 92, automatically placing a positive voltage on the grid of tube 53, acting thereon through resistors 70 and 92. Consequently tube 53 continues to draw maximum plate current and keeps alarm relay 54 activated.

If antenna 10 is cut or broken, or if a fusible link or thermostatic switch opens, the junction between resistors 50 and 51, which normally is grounded for D. C. through coils 21 and 22, becomes ungrounded. Under such condition, B+ acts on the grid of tube 53 through resistors 50 and 51, inducing a positive effective potential between grid and cathode. The tube consequently draws maximum current and activates the alarm relay. In this fashion, the equipment provides warning against both fire and malfunctioning of the antenna system.

In addition to the control of the alarm stage, the voltage output from across resistor 45 also controls or acts upon the automatic frequency control stage 16, to maintain said voltage output at or near value B specified in Figure 2 during normal on-guard operation. This action compensates for slow frequency drifts in the system, no matter from what cause. The action, however, is sufficiently slow so that the system cannot be penetrated even by a carefully calculated approach, without setting off the alarm.

Operation of the automatic frequency control stage 16 is as follows: Tube 65 is biased by the resistor network consisting of 96 and 66 so that with an applied voltage of value B (see Figure 2) applied to the grid through isolating resistor 68, the current in the tube is such that the SPDT relay 64 is just activated. The poles of this relay are connected to a reversible A. C. motor 58. Condenser 59 and resistor 60 used therewith provide electrical phase shift for motor starting purposes. When the relay 64 is activated connections to the motor are such as to cause rotation in one direction; and when relay 64 is not activated, connections to the motor are changed to cause it to rotate in the opposite direction. Since motor 58 is mechanically coupled to condenser 19, a signal across resistor 45 greater than value B will activate relay 64, causing motor 58 to rotate condenser 19 in such direction as to decrease its value, the frequency will therefore increase, and the output from the crystal stage will move down along the curve to a value less than B. When a value less than B exists at the output of the crystal stage, relay 64 will be deactivated, motor 58 will reverse direction, condenser 19 will increase in value, and the output of the crystal stage will rise toward value B. In this fashion, since the motor is geared down tremendously, and operated at a very slow speed, a slowly acting correction is secured to maintain the output of the crystal stage within a small predetermined frequency range in the vicinity of point B during the on-guard condition.

The circuitry described above operates very satisfactorily when the multiplied frequency of the oscillator stage is on the higher-frequency slope of the crystal response curve shown in Fig. 2, such as in the vicinity of point B. However, when the equipment is first put on, there is no guarantee that the multiplied oscillator frequency will be in the vicinity of point B, or, in fact, near the response curve at all. To avoid the necessity of adjustment by the user initially, to bring the oscillator frequency to the proper value for the on-guard condition, and to accomplish a number of other functions, the control contactor 17 comes into operation.

Before this item is described, the motor circuitry for obtaining both high and low motor speeds electrically will be discussed. It is well known that motor speeds may be varied over a considerable range by electrical means. However, if a normal speed motor is slowed down sufficiently by decreasing the voltage available to it, a point of instability is reached, and the motor comes to a stop. Values of speed between this point of instability and zero cannot be maintained. This action occurs for both A. C.

6

and D. C. motors. In view of the fact that (1) a normal motor speed is required in the equipment on starting, and (2) a speed sufficiently slow so as to have a value in the motor instability zone is required to maintain the equipment in the on-guard condition, means were developed to accomplish this objective electrically.

Fig. 3 shows a representative speed versus torque curve for an induction motor. Self-starting synchronous motors have a similar curve, except that at synchronous speed the torque curve is perpendicular to the abscissa. An inspection of this curve shows that a value of torque T_1 corresponds to two values of speed, namely S_1 and S_2 . Consequently, if torque T_1 is present at starting, the speed of the motor will be S_1 ; whereas if the load is applied after the motor has reached full speed, the speed will fall to S_2 . This principle is utilized in obtaining the tremendous differences of speed required for proper operation of the equipment.

Loading of the motor is obtained magnetically by passing direct current through one or more windings. The magnetic field produced by this direct current induces opposing currents as a result of relative motion between rotor and stator, thus providing a drag on the rotating structure. This magnetic loading or drag can be adjusted to any desired amount merely by adjusting the direct current in the winding.

To obtain the required slow speed in the equipment, rectifier 62 and resistor 63 have been inserted in the motor circuit. The resistor determines by the drop across it the voltage to be applied to the rectifier, and so regulates the amount of direct current flowing in the winding of the motor. The resulting drag determines therefore the load on the motor. By shorting out the combination of resistor and rectifier, the motor runs at normal speed during the starting of the equipment. This shorting action at the start is accomplished by the control contactor mentioned previously.

It should be noted that a parallel method of feeding the direct current to the motor can also be utilized if desired, and the same sort of magnetic loading is obtained.

Control contactor 17 programs the starting of the equipment in such fashion that a human operator becomes unnecessary in the adjustment and alignment of the system. The contactor is comprised in essence of a resistive element 70, heating a thermostatic strip 104 carrying contacts 97, 98, 99, 100, and 101. These contacts open associated circuits at predetermined times as the thermostatic element heats up, and maintain this open-circuit condition as long as energy is applied to resistive element 70.

The function of the various contacts are as follows: contact 101 permits B+ voltage to be applied to low voltage cutout stage 18. Consequently relay 73 is activated, and B+ is applied to the equipment, through contact 103. Shortly thereafter, as the thermostatic element warms up, contact 101 opens. It can be readily seen that if line voltage should fail, B+, which is derived therefrom, will disappear, relay 73 will be deactivated and B+ voltage connection will be removed from the equipment circuitry. If line voltage should return, the equipment will still not operate until such time as contact 101 should close again after sufficient cooling of the contactor to activate relay 73. The objective here is to permit the program of operations to recycle in proper sequence, thus avoiding the possibility of false alarms. In this connection, it should be noted that regulation of voltages will provide improved equipment performance.

Contact 100 places a positive bias on tube 65, causing motor 58 to rotate condenser 19 for such period of time as to decrease its capacitance to minimum. In this fashion, the condenser will be put into a fiducial position which will permit it to select the proper on-guard frequency falling within its range of capacitance. It will be noted that this capacitance range corresponds to a relatively

large oscillator frequency range. After the minimum capacity has been attained, contact 100 opens, deactivating relay 64, causing motor 58 to turn in the opposite direction, and consequently rotating condenser 19 toward maximum capacity. Immediately thereafter, contact 97 opens, placing the "slowing" elements, rectifier 62 and resistor 63, into the motor circuitry. However, the motor still continues near full speed, though, as indicated previously, it will drop to a very slow speed if line voltage is momentarily interrupted. Condenser 19 increases in capacitance, and the frequency of oscillator stage 12 correspondingly decreases as motor 58 rotates, until the frequency acting on the crystal stage reaches a point causing an output slightly greater than point B (see Fig. 2). At this point, as indicated previously, relay 64 is activated, causing motor 58 to reverse. The momentary interruption of line voltage to the motor during reversal causes the motor to drop to its slow mode of operation. Shortly thereafter, contact 99 opens, effectively removing resistor 91 from its parallel connection to resistor 28, shifting the frequency of oscillator stage 12 to a higher value, the exact amount being slightly more than the sum of the shift caused by the inertia of the motor-condenser mechanical system in dropping from high to low speed operation and necessary programming time. The slow speed operation of the motor then causes the frequency to decrease very slowly up to point B on the curve shown in Figure 2. Thereafter, automatic frequency control maintains operation in the vicinity of point B.

Since the inductance in oscillator stage 12 remains substantially constant, the total capacitance associated therewith required to maintain the frequency at point B must also be substantially constant during on-guard operation of the equipment. Slow changes in antenna capacitance due to changes in weather or other causes will, therefore, merely cause compensating changes in condenser 19, so that total capacitance continues substantially constant. However, slight changes in total capacitance may occur if other oscillator circuit elements should be effected by heat, loading, or other causes.

Finally contact 98 opens, ungrounding the grid of alarm tube 53, and the entire equipment is now effectively on-guard.

If the alarm system is now activated by the approach of an intruder, relay 54 will operate to sound alarm 55. In so doing, its normally-closed contact will open and remove energy from heating element 70 of the control contactor. B+ will then act on the grid of tube 53 through resistors 70 and 92 to maintain the action of alarm 55 thereafter. B+ also acts on the grid of tube 65 through resistors 70 and 69, thereby causing motor 58 to rotate condenser 19 in such direction as to increase the frequency. These actions continue for a preset interval of time. At the end of this interval, the thermostatic element of the contactor has cooled down to the point where contact 98 is made, grounding thereby the grid of tube 53. This removes the aforesaid B+, and causes a drop of current in tubes 53 and 65. Motor 58 reverses and starts moving the frequency toward point B. Relay 54 becomes deactivated, the alarm ceases to sound, voltage is reapplied to heating element 70, and the contactor starts moving to its on-guard position. Shortly thereafter contact 98 opens, and, as soon as the frequency has reached point B, the equipment is responsive to another intrusion.

This reset type of operation is advantageous in a home where the occupants are away on vacation or otherwise, and it is desired to frighten off intruders by the alarm; but where it is not desirable to have the alarm sounding off continuously after it has accomplished its purpose.

Certain advantages may be obtained if the automatic frequency control stage 16 is modified as shown in Figure 4. Among these advantages may be listed the following:

(1) During on-guard periods when automatic frequency

control is not required, the motor is off. (2) Automatic frequency control when correcting up the curve toward point B (see Figure 2) can be made to occur at a faster rate than when correcting down the curve toward point B. These advantages promote more efficient and effective operation of the equipment.

The major difference of the circuitry of Figure 4 over the automatic frequency control stage 16 of Figure 1 lies in the use of two relays, 64a and 64b, to replace relay 64. Relay 64b is made less sensitive than relay 64a, such as by placing resistor 77 across relay 64b. While the current in tube 65 is rising toward a value corresponding to point B (see Fig. 2) under on-guard conditions, neither relay is activated, resistor 63b is in parallel with rectifier 62, and the motor is rotating in such direction as to decrease the frequency of the system. When the current reaches point B, relay 64a is activated, power is removed from the motor, and resistor 63a is placed across rectifier 62. If the current in tube 65 continues to increase, relay 64b is activated in addition, thereby removing resistor 63b from across rectifier 62, and also activating the motor to turn in the reverse direction. This action will increase frequency and decrease current in tube 65. Resistors 63a and 63b have been selected to permit two different speeds respectively during motor forward and reverse rotation.

As the current in tube 65 decreases, the reverse action described immediately previous occurs, though the precise currents required for deactivations of the relays will not be exactly the same as those required for activation. Operation, however, is not adversely affected thereby.

An alternative method of electrically obtaining the extreme ratio of speeds required by the automatic frequency control system is shown in Fig. 5. This system, in contradistinction to the method previously described, may be used with both A. C. and D. C. self-starting motors. The principle employed is that of applying pulses of current to the motor. Each pulse is of such intensity and duration that it will cause the motor to move slightly and then come to a halt. Subsequently pulses repeat this process. By selection of the proper pulse intensity, width, and repetition rate, an extremely wide variety of "slow speeds" may be obtained. For example, one motor tested with a normal speed of 3600 R. P. M., was reduced in speed by this principle to 0.1 R. P. M., a ratio of 36,000:1. Fig. 5 illustrates one form in which this principle of pulsing is utilized. The motor 76 in this particular embodiment is a D. C. reversible type. The current pulser 75 is of the thermal type, in which a thermostatic element 80, heated by thermal element 81, shorts out said thermal element, thereby applying full current to motor 76 and causing it to start to rotate. Almost immediately, however, because thermal element 81 is shorted out, thermostatic element 80 starts cooling and breaks contact, removing full current from the motor. The motor stops rotating. The cycle then repeats. It should be pointed out that this thermal type of current pulser was used for illustration, and that there are numerous other types available, such as relay pulsers, radio tube pulsers, rotary pulsers, and the like. Radio tube pulsers are advantageous in that pulse intensity, width, and repetition rate are very easily adjustable.

Fig. 6 illustrates a non-mechanical method of obtaining automatic frequency control. A Hartley triode-type oscillator, is utilized in the oscillator stage, with condensers 82 and 83 in series present in the grid circuit. Condenser 83 is the grid condenser normally in this type of circuit, and resistor 84 is the grid leak. Condenser 82 and the plate circuit of tube 87 form an RC network, the resistance of which is varied by changing the bias on the grid of tube 87. Consequently, the phase of grid excitation of the oscillator tube can be varied electronically, and hence its frequency. Resistor 86 permits potential to be applied to the plate of tube 87, and is made as high in value as possible to minimize loading effects. Condenser 88 is

of relatively high value, resistor 89 is of sufficiently high value to provide the required high time constant in conjunction with condenser 88, and resistor 90 is relatively low in value to give a comparatively short time constant when employed with condenser 88.

Operation of this non-mechanical automatic frequency control stage is as follows: When the equipment is first turned on, no bias exists on tube 87, its plate resistance is therefore low, and the frequency of the oscillator stage, which is controlled by this plate resistance in its grid circuitry, is therefore at its highest value. Since, at the beginning, resistor 89 is shorted out by contact 97, condenser 88 starts charging up through resistor 90 from the negative bias point existing at the junction of resistors 41 and 42. The frequency of the oscillator consequently starts moving to a lower value, until it reaches a value corresponding to point B on the curve of Fig. 2. At this point considerable positive voltage develops across resistor 45 to the point where the negative potential formerly existing across resistors 42 and 45 (which was applied to condenser 88 through resistor 90), is reduced sufficiently to prevent further charging of condenser 88. Consequently, the frequency stabilizes in the neighborhood of point B, and automatically maintains itself there. Subsequently, contact 97 opens, placing resistor 89 in the charging circuit, and thereby making the time constant sufficiently high to take care of extremely slow frequency drifts. The equipment is now on-guard again.

The invention described herein includes a number of stages or elements, preferred arrangements of which have been described. However, certain variations in circuitry are possible without departing from the spirit of the invention. For example, in Fig. 1, the frequency multiplier stage 13 could be omitted, and the crystal stage could be connected directly to the oscillator stage. Though satisfactory operation could be achieved certain disadvantages would be present. If a low-cost relatively high-frequency crystal were utilized, the oscillator stage would have to operate in the much-crowded radio spectrum with possible interference thereto. In addition, power losses would be greater. On the other hand, if the frequency of the oscillator stage were low, the cost of a crystal to operate directly at these frequencies would be prohibitively expensive.

As another example, to obtain the extreme ratios of motor speed required for proper operation of the system, as described previously, two motors, one relatively high speed, and the other geared down to the desired slow speed could be employed. However, a differential gear system would be required to mechanically intercouple the two motors with the load. This method is costly, and requires more specialized equipment to accomplish, over that shown in the preferred embodiments.

Then again, the precise method outlined herein for determining changes in antenna capacitance need not be utilized in order to obtain the highly desirable features of automatic adjustment and control described in my invention. The automatic features could be applied, for example, to a capacitance sensing system comprised of an oscillator and antenna similar to that described herein, except that the output of said oscillator (in the form of harmonics thereof, if desired), would beat with the output of another oscillator, or its harmonics. The change in the beat frequency with antenna capacitance changes in the above described oscillatory system could then be converted into a voltage similar in effect to that appearing across resistor 45 of Fig. 1, to control the automatic circuitry.

The same general comments are applicable to bridge or other type methods of determining capacitance changes.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that changes and modifications may be made therein without departing from the invention, and it is therefore aimed in the

appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. An alarm system having an initial automatic adjustment period preceding on-guard operation comprising in combination: an antenna circuit with total capacitance to ground falling within a first capacitance range during on-guard operation of said alarm system; a variable condenser operatively connected to said antenna circuit whereby the total capacitance to ground of said antenna circuit may be varied by said condenser through a second capacitance range which includes said first capacitance range; first means for varying the capacitance of said condenser at a relatively fast rate through said second capacitance range during said initial adjustment period; second means for providing a voltage responsive to said antenna capacitance when said first capacitance range is reached, whereby changes in antenna capacitance produce corresponding changes in said voltage; third means responsive to said voltage for producing a relatively slow rate of condenser variation thereafter; fourth means responsive to relatively slow variations in said voltage to maintain said antenna capacitance substantially constant; and fifth means responsive to a relatively fast variation in said voltage in attaining a predetermined amplitude to activate an alarm.
2. The alarm system as stated in claim 1, in which the antenna is a closed circuit containing thermally-activated circuit-opening elements, and to which said alarm system means responsive to the opening of said circuit to activate an alarm have been included.
3. An alarm system having an initial automatic adjustment period preceding on-guard operation comprising in combination: an oscillatory system, the output frequency of which is maintained within a first frequency range during on-guard operation of said alarm system; an antenna having capacitance to ground operatively connected to, and effectively constituting part of said oscillatory system, whereby changes in antenna capacitance produce changes in oscillatory system output frequency; means operative during said initial adjustment period for varying the said output frequency at a relatively fast rate within a second frequency range which includes said first frequency range; means for producing a relatively slow rate of output frequency variation of said oscillatory system when said first frequency range is attained; a discriminator for providing a voltage responsive to the output frequency of said oscillatory system; means responsive to relatively slow variations in said voltage to maintain the output frequency of said oscillatory system within said first frequency range; and means responsive to a relatively fast variation in said voltage in attaining a predetermined amplitude to active an alarm.
4. The alarm system as stated in claim 3, in which the antenna is a closed circuit containing thermally-activated circuit-opening elements, and to which said alarm system means responsive to the opening of said circuit to activate an alarm have been included.
5. The alarm system as stated in claim 3, to which has been added means responsive to said voltage to warn of system malfunctioning when, subsequent to said initial adjustment period, said voltage is produced by a frequency outside said predetermined range.
6. An alarm system having an initial automatic adjustment period preceding on-guard operation comprising in combination: an oscillator including a tank circuit, the frequency of said oscillator being maintained within a first frequency range during on-guard operation of said alarm system; an antenna having capacitance to ground operatively connected to said tank circuit, whereby changes in antenna capacitance produce changes in frequency of said oscillator; means operative during said initial adjustment period for varying the frequency of said oscillator at a relatively fast rate within the second frequency range

which includes said first frequency range; means for producing a relatively slow rate of frequency variation of said oscillator when said first frequency range is attained; a discriminator for providing a voltage responsive to the frequency of said oscillator; means responsive to, relatively slow variations in said voltage to maintain frequency of said oscillator within said first frequency range; and means responsive to a relatively fast variation in said voltage in attaining a predetermined amplitude to activate an alarm.

7. An alarm system having an initial automatic adjustment period preceding on-guard operation comprising in combination: a harmonic-producing oscillator employing a fundamental frequency maintained within a first frequency range during on-guard operation of said alarm system, said oscillator having a tank circuit and an amplifier, said tank circuit including two coils in series, a first coil the output of which is utilized for driving said amplifier, and a second coil fed by the output of said amplifier and inductively coupled to said first coil for maintaining said tank circuit in oscillation; said second coil being so adjusted relative to the first coil that the mutual inductance between said coils is sufficiently reduced from unity to permit substantial output at a selected harmonic from across each coil when capacitatively tuned; an antenna having capacitance to ground operatively connected to said tank circuit whereby changes in antenna capacitance produce changes in frequency of said oscillator; means operatively associated with said oscillator for varying the frequency thereof during said initial adjustment period at a relatively fast rate within a second frequency range which includes said first frequency range; means for producing a relatively slow rate of frequency variation when said first frequency range is attained; a discriminator effectively acting thereafter for converting the selected harmonic output of said oscillator into a corresponding voltage; means responsive to slow variations in said voltage to maintain the frequency of said oscillator within said first frequency range; and means responsive to a relatively fast variation in said voltage in attaining a predetermined amplitude to activate an alarm.

8. The alarm system as stated in claim 1 in which the first and third means are comprised of: a self-starting reversible motor mechanically coupled to rotate said condenser and activated from an alternating-current source, said motor having a torque-speed characteristic adaptable for providing under magnetic loading of said motor two separate rotational speeds, a high rotational speed for use during said initial adjustment period and a slow rotational speed for use when said first capacitance range is reached; first programming means operatively associated with said motor during said initial adjustment period to cause said motor to rotate said condenser at said high speed to minimum capacity limit of said second capacitance range; second programming means acting once thereafter to provide a reversal of motor rotation of said condenser; third programming means effective immediately after said reversal for application to said motor of a suitable direct current in addition to the said alternating-current source to provide said magnetic loading, whereby the reduction in motor speed effected by a motor reversal or otherwise causes said motor to operate at said slow rotational speed; motor reversing means responsive to said voltage, said motor reversing means acting initially at a value of said voltage corresponding to the upper limit of said first capacitance range to change direction of motor rotation, and acting at values of said voltage respectively corresponding to the lower and upper limits of said first capacitance range thereafter; and means for deactivating said motor over a portion of said first capacitance range.

9. An alarm system having an initial automatic adjustment period preceding on-guard operation comprising in combination: an oscillator including a tank circuit, the frequency of said oscillator being maintained within a first frequency range during on-guard operation of said

alarm system; an antenna circuit having capacitance to ground operatively connected to said tank circuit, said antenna circuit including a variable condenser, whereby changes in antenna circuit capacitance produce changes in frequency of said oscillator; first means for varying the capacitance of said condenser at a relatively fast rate during said initial adjustment period to cause the frequency of said oscillator to vary through a second frequency range which includes said first frequency range; second means for providing a voltage responsive to frequency of said oscillator when said first frequency range is reached, whereby changes in oscillator frequency produce corresponding changes in said voltage; third means responsive to said voltage for producing a relatively slow rate of condenser variation thereafter; fourth means responsive to relatively slow variations in said voltage to maintain frequency of said oscillator substantially constant; and fifth means responsive to a relatively fast variation in said voltage in attaining a predetermined amplitude to activate an alarm.

10. The alarm system as stated in claim 1 in which the first and third means are comprised of: a self-starting reversible motor mechanically coupled to rotate said condenser and activated from an alternating-current source, said motor having a torque-speed characteristic adaptable for providing under magnetic loading of said motor two separate rotational speeds, a high rotational speed for use during said initial adjustment period and a slow rotational speed for use when said first capacitance range is reached; first programming means operatively associated with said motor during said initial adjustment period to cause said motor to rotate said condenser at relatively high speed to minimum capacity limit of said second capacitance range; second programming means acting once thereafter to provide a reversal of motor rotation of said condenser; third programming means effective immediately after said reversal for application to said motor of a suitable direct current in addition to the said A. C. source to provide said magnetic loading, whereby the reduction in motor speed effected by a motor reversal or otherwise causes said motor to operate at said slow rotational speed thereafter; motor reversing means responsive to said voltage, said motor reversing means acting initially at a value of said voltage corresponding to the upper limit of said first capacitance range to change direction of motor rotation, and acting at values of said voltage respectively corresponding to the lower and upper limits of said first capacitance range thereafter.

11. The alarm system as stated in claim 1 in which the first and third means are comprised of: a self-starting reversible motor mechanically coupled to rotate said condenser and activated from an alternating current source, said motor having a torque-speed characteristic adaptable for providing under magnetic loading of said motor two separate rotational speeds, a high rotational speed for use during said initial adjustment period and a slow rotational speed for use when said first capacitance range is reached; first programming means operatively associated with said motor during said initial adjustment period to cause said motor to rotate said condenser at relatively high speed to minimum capacity limit of said second capacitance range; second programming means acting once thereafter to provide a reversal of motor rotation of said condenser; third programming means effective immediately after said reversal for application to said motor of a suitable direct current in addition to the said alternating current source to provide said magnetic loading, whereby the reduction in motor speed effected by a motor reversal or otherwise causes said motor to operate at said slow rotational speed thereafter; fourth programming means for providing a reduction in said antenna capacitance by a predetermined amount after said motor attains slow rotational speed, whereby said predetermined amount slightly overcompensates for

13

amount of said condenser inertially-caused overshoot in changing from said high rotational speed to said low rotational speed; fifth programming means to return said alarm system to said on-guard condition a predetermined time after activation by an intruder; motor reversing means responsive to said voltage, said motor reversing means actively initially at a value of said voltage corresponding to the upper limit of said first capacitance range to provide a given direction of motor rotation, acting immediately after said reduction in antenna capacitance to cause the opposite direction of motor rotation, and acting thereafter at a value of said voltage corresponding to the upper and lower limits of said first capacitance range to provide said given and said opposite directions of motor rotation respectively.

12. The alarm system as stated in claim 9 in which: the antenna is a closed circuit containing thermally-activated circuit-opening elements; means responsive to the opening of said circuit to activate an alarm have been added; and means have been included responsive to said voltage to warn of system malfunctioning when, subsequent to said initial adjustment period, said voltage is produced by a frequency outside said first frequency range.

13. The alarm system as stated in claim 9 in which the said first and third means are comprised of: a self-starting reversible motor mechanically coupled to rotate said condenser and activated from an alternating-current source, said motor having a torque-speed characteristic adaptable for providing under magnetic loading two separate rotational speeds, a high rotational speed for use during said initial adjustment period and a slow rotational speed for use when said first frequency range is reached; first programming means operatively associated with said motor during said initial adjustment period to cause said motor to rotate said condenser at relatively high speed to the capacity corresponding to high frequency limit of said second frequency range; second programming means acting once thereafter to provide a reversal of motor rotation of said condenser; third programming means effective immediately after said reversal for application to said motor of a suitable direct current in addition to the said alternating-current source to provide said magnetic loading, whereby the reduction in motor speed effected by reversal or otherwise causes said motor to

14

operate at said slow rotational speed thereafter; motor reversing means acting initially at a value of said voltage corresponding to the lower limit of said first frequency range to change direction of motor rotation, and acting at a value of said voltage corresponding to the upper and lower limits of said first frequency range thereafter.

14. The alarm system as stated in claim 9 in which the said first and third means are comprised of: a self-starting reversible motor mechanically coupled to rotate said condenser, said motor being adaptable to rotate at relatively high speed when terminals of said motor are connected to a suitable source of electricity; current-interrupting means capable of being interposed between terminals of said motor and said source of electricity to provide a relatively slow rotational motor speed; first programming means operatively associated with said motor during said initial adjustment period to cause said motor to rotate said condenser at said high speed to the capacity corresponding to the high frequency limit of said second frequency range; second programming means following to provide a single reversal of motor rotation of said condenser; motor reversing means acting thereafter when values of said voltage corresponding to the higher and lower limits respectively of said first frequency range are reached; third programming means for inserting said current-interrupting means between said motor terminals and said source of electricity, whereby said condenser is caused to operate at said slow speed.

15. The alarm system as stated in claim 9 in which means are included to prevent sounding of the alarm during said initial adjustment period.

16. The alarm system as stated in claim 9 in which means responsive to the amplitude of line voltage have been included to prevent false alarms when said line voltage is improper, and to provide an initial adjustment period when said line voltage becomes proper again.

References Cited in the file of this patent

UNITED STATES PATENTS

1,658,953	Theremin	Feb. 14, 1928
2,112,826	Cook	Apr. 5, 1938
2,490,238	Simons	Dec. 6, 1949
2,708,746	Shaw	May 17, 1955