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Evaluation of the Johnson AG 1007-7 (G-7) Microwave Motion Detection System

Department 1730

Sandia Laboratories

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EVALUATION OF THE JOHNSON AG-1007-7 (G-7) MICROWAVE MOTION DETECTION SYSTEM

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ABSTRACT

A series of tests was performed on the Johnson Model AG-1007-7 motion detection system. The primary objectives of these tests were to determine sensor detection patterns and to quantitate the effects of intruder velocity. System susceptibility to fluorescent lights, oscillatory motion, and environmental factors was also examined.

ACKNOWLEDGMENT

Test planning, data analyses, and text preparation were performed by W. P. Brigham. The text was critically reviewed and edited by J. D. Williams. This work was sponsored by the U.S. Department of Energy, Office of Safeguards and Security (DOE/OSS).

CONTENTS

Section		Page
1	GENERAL DESCRIPTION	7
2	INTRUDER DETECTION THEORY	9
	2.1 Evaluation Approach	9
	2.2 Principles of Operation and Test Parameters	9
3	INTRUDER DETECTION CHARACTERISTICS	13
	3.1 Electronic Radial Detection Patterns	13
	3.2 Walk-Test Patterns	13
	3.3 Effects of Intruder Velocity and Range Setting	15
	3.4 Detector Sensitivity	17
	3.5 Tunable Oscillator	18
4	FALSE ALARM TESTS	19
	4.1 Oscillatory Motion Test	19
	4.2 Fluorescent Light Test	19
5	ENVIRONMENTAL TESTS	21
ATTACHMENT 1		23

ILLUSTRATIONS

Figure		
1	The Principle of Monostatic Doppler Motion Detectors	10
2	Spherical Coordinate System Used in This Evaluation	11
3	Electronic Detection Patterns for Johnson AG-1007-7	13
4	Johnson AG-1007-7, Microwave Radial Pattern, Range Setting 2	14
5	Johnson AG-1007-7, 0° Pattern, Range Setting 2	14
6	Johnson AG-1007-7, 90° Pattern, Range Setting 2	14
7	Johnson AG-1007-7, +45°, -135° Pattern, Range Setting 2	14
8	Johnson AG-1007-7, -45°, +135° Pattern, Range Setting 2	15
9	Johnson AG-1007-7, Composite of All Walk-Test Patterns	15
10	Johnson AG-1007-7 Velocity Effects	16
11	Johnson AG-1007-7 Range Setting Effects	16
12	Johnson AG-1007-7 Detector Sensitivity Effects	17
13	Johnson AG-1007-7 Frequency Setting	18

TABLE

Table		
I	Environmental Test Results	21

EVALUATION OF THE JOHNSON AG-1007-7 (G-7) MICROWAVE MOTION DETECTION SYSTEM

1. GENERAL DESCRIPTION

The Johnson Model AG-1007-7, also known as the Johnson G-7, is a monostatic microwave motion detection system manufactured by Johnson Controls, 507 East Michigan Street, Milwaukee, Wisconsin. It has an adjustable operating frequency of 2.45 GHz ± 8 MHz. The standard antenna has a pattern which is adjustable up to a maximum area of 30.5 by 12 metres. Detection sensitivity is adjustable. There is a fail-safe circuit, an anti-jam detector and line supervision, and a light-emitting diode (LED) alarm indicator for walk-testing. The power required is 60-Hz, 24 volts ac, which is provided by a 120/24-volt ac transformer. There are three different standby power supplies available as options.

The manufacturer's operation and installation manual is included as Attachment 1 to this report.

2. INTRUDER DETECTION THEORY

2.1 EVALUATION APPROACH

The Johnson Model AG-1007-7 is a monostatic (receiver and transmitter at the same location) motion detector which detects the Doppler frequency shift produced by reflections from moving intruders. This type of system can be used in rooms of various types and sizes. Since detection is based on line-of-sight criteria, the radar-range detection evaluation approach can be used.*

The methods used for evaluating motion detection characteristics are mainly walk-tests. These walk-tests are done in a large open room, approximately 16 by 16 by 3.6 metres, to determine detection patterns, velocity factors, and range setting effects on the detection patterns. Radial detection patterns are also determined by electrically measuring the transmitted power patterns. Temperature effects are grossly determined at -15° C and 57° C by walk-tests. In order to allow a more comprehensive evaluation of temperature effects to be obtained, an electronic simulation is used which simulates the intruder by injecting, at the receiver, an electromagnetic signal which is proportional to the intruder's velocity toward and distance from the sensor. Results obtained at regular intervals, combined with periodic walk-tests for verification, will be presented in a later report.

2.2 PRINCIPLES OF OPERATION AND TEST PARAMETERS**

The operational principle of a monostatic motion detector that uses a Doppler shift to detect intruder movement is illustrated in Figure 1. These types of detectors are similar to conventional radar systems in that radar-range equations are applicable. However, motion detectors use continuous-wave signals and frequency-modulation detectors to detect the Doppler shifts.

The far-field transmitted power density, P_T, in watts/metre^2 (W/m^2), of the radiated signal measured at the intruder position (R,ϕ,θ) at the center frequency of the detector, f_o, is given by

$$P_T(R,\phi,\theta) = \frac{P_T(1,0,90)\,G_T(\phi,\theta)}{R^2} \qquad \text{for } R \geq 1.0 \text{ metre} \qquad (1)$$

*The transmitted power in a wave varies as $1/R^2$ referenced to the transmitter: the wave is reflected from an intruder and this reflection varies as $1/R^2$ referenced to the intruder.

**This section closely follows the corresponding section of SAND77-1218, Evaluation of Three Multi-Transceiver Ultrasonic Intrusion Detectors--Advisor VI, Contronic MD440 and Detection Systems DS600, June 1978.

where

(R,ϕ,θ) = location of the intruder in spherical coordinates (see Figure 2), R is in metres, ϕ and θ are in degrees,

$P_T(1,0,90)$ = reference power-density measurement at 1 metre (W/m^2),

$G_T(\phi,\theta)$ = power gain associated with the transmitter transducer referenced to the (0,90) location (see Figure 2), and

$P_T(R,\phi,\theta)$ = transmitted power density at the intruder location (W/m^2).

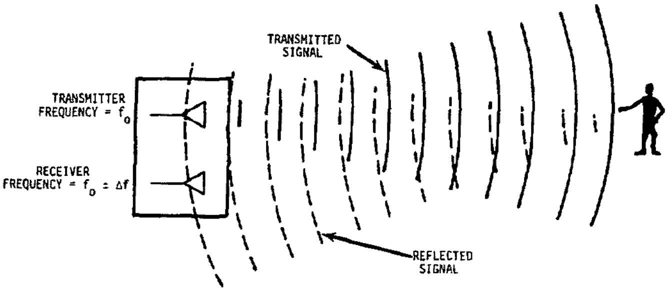


Figure 1. The Principle of Monostatic Doppler Motion Detectors

The transmitted power is reflected by the effective cross section of the intruder and returned to the receiver at a frequency of $f_o \pm \Delta f$. The power density of the reflected signal is given by

$$P_R(0,\phi,\theta) = \frac{P_T(R,\phi,\theta) A G_R(\phi,\theta) \lambda^2}{(4\pi R)^2} \qquad (2)$$

where

A = effective reflective area of the intruder (m^2), assumed constant over the bandwidth of a particular system,

$G_R(\phi,\theta)$ = power gain associated with the receiver referenced to the (0,90) location, and

λ = wavelength of f_o (metres).

Note that the Doppler shift and the radial velocity component of the intruder are related by

$$\Delta f = \frac{2 f_o V_r}{c} \qquad (3)$$

where

c = wave propagation velocity (3×10^8 m/s microwave or 344 m/s ultrasonic),

V_r = radial velocity component of intruder (m/s), and

f_o = transmitter center frequency.

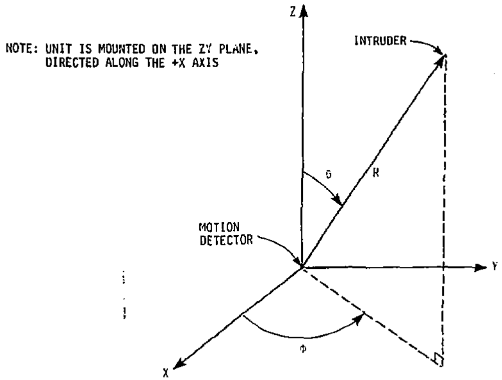


Figure 2. Spherical Coordinate System Used in This Evaluation

Combining Eqs. 1 and 2 yields

$$P_R(0,\phi,\theta) = \frac{P_T(1,0,90)AG_T(\phi,\theta)G_R(\phi,\theta)\lambda^2}{(4\pi)^2R^4} \quad (4)$$

There is a threshold value of P_R which, if exceeded for a short time, will trigger the alarm of the detector. This threshold determines the maximum radius of detection for a given set of intruder conditions (intruder area A, location (R, φ, θ), and radial velocity V_r). Thus,

$$P_{RD}(0,\phi,\theta) = \frac{P_T(1,0,90)AG_T(\phi,\theta)G_R(\phi,\theta)\lambda^2}{(4\pi)^2R_D^4} \quad (5)$$

where

$P_{RD}(0,\phi,\theta)$ = detector power-density alarm threshold for a given Δf; R_D is the radius of detection at the location of the intruder where $P_R = P_{RD}$.

The radius of detection is

$$R_D \approx \left[\frac{P_T(1,0,90)AG_T(\phi,\theta)G_R(\phi,\theta)\lambda^2}{(4\pi)^2 P_{RD}(0,\phi,\theta)}\right]^{1/4} \quad (6)$$

3. INTRUDER DETECTION CHARACTERISTICS

3.1 ELECTRONIC RADIAL DETECTION PATTERNS

The relative intrusion detection patterns, which were determined by electronically measuring the transmitted power patterns (G_T of Section 2.2), are shown in Figure 3. Since the same antenna is used to receive the Doppler shifted frequency in a monostatic detector, $G_T = G_R$. Thus, the relative special detection patterns (with no electronic processing delays) are obtained by determining the square root of G_T after normalization. This procedure provides gross confirmation of the radial walk-tests (Section 3.2) and provides vital information on proper tilt angles for the sensor.

3.2 WALK-TEST PATTERNS

Walk-test patterns for the Johnson AG-1007-7 are illustrated in Figures 4 through 8. Figure 9 is a composite of the five walk-test patterns. For the composite, intruder motion in any direction within the pattern would generate an alarm.

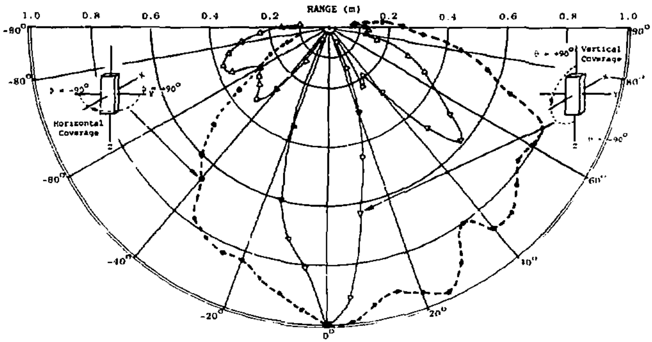


Figure 3. Electronic Detection Patterns for Johnson AG-1007-7

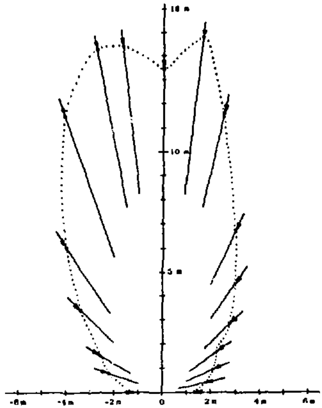


Figure 4. Johnson AG-1007-7, Microwave Radial Pattern, Range Setting 2

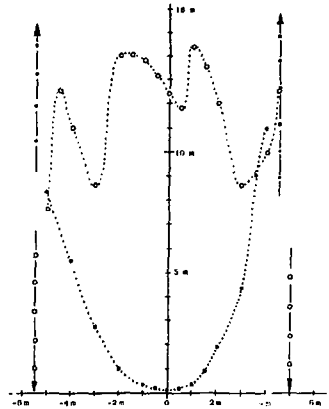


Figure 5. Johnson AG-1007-7, 0° Pattern, Range Setting 2

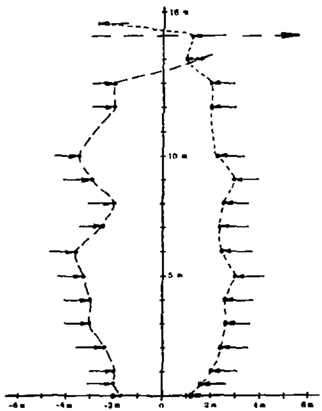


Figure 6. Johnson AG-1007-7, 90° Pattern, Range Setting 2

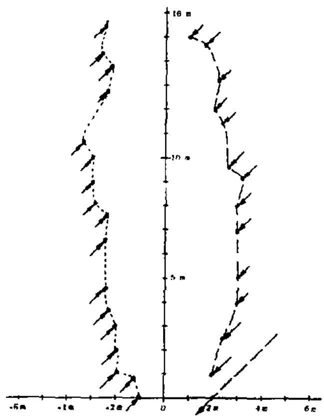


Figure 7. Johnson AG-1007-7, +45°, -135° Pattern, Range Setting 2

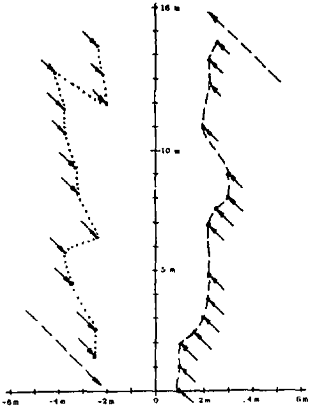


Figure 8. Johnson AG-1007-7, -45°, +135° Pattern, Range Setting 2

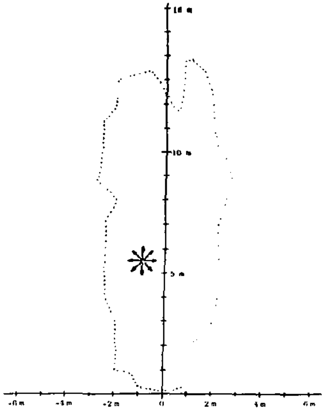


Figure 9. Johnson AG-1007-7, Composite of All Walk-Test Patterns

All of the walk-test patterns were obtained by actual use of a 68-kg, 1.73-metre-tall human walking at a velocity of 0.5 metre per second. Each step was synchronized to the beat of an electronic metronome; the metric distance for each step was marked on the floor. One minute was allowed between tests. All tests were performed with a range setting of 0.5. The range setting was chosen to restrict the detection patterns to lie within the walk-test area.

3.3 EFFECTS OF INTRUDER VELOCITY AND RANGE SETTING

A curve which shows the effects of intruder velocity is illustrated in Figure 10; the effects of range setting are shown in Figure 11. The dashed curve in Figure 11 was obtained with an absorbing (nonreflecting) floor; the other curve was calculated from the dashed curve. The data in Figures 10 and 11 are used with the walk-test patterns (Section 3.2) to expand the walk-test curves in the radial direction. This expansion is accomplished in four steps:

1. Find the multiplication factor from Figure 10.
2. Find the multiplication factor from Figure 11. Use the With Reflection curve for metallic or earth floors and the Without Reflection curve for wood or concrete floors.
3. Multiply both of the factors times the Maximum Range number given on the appropriate Range Setting Multiplication Factor curve in Figure 11.
4. The resultant number is then divided by the y-axis/pattern intersection point from the radial walk-test patterns or the 0° walk-test pattern. Both axes of all curves are now multiplied by this quotient.

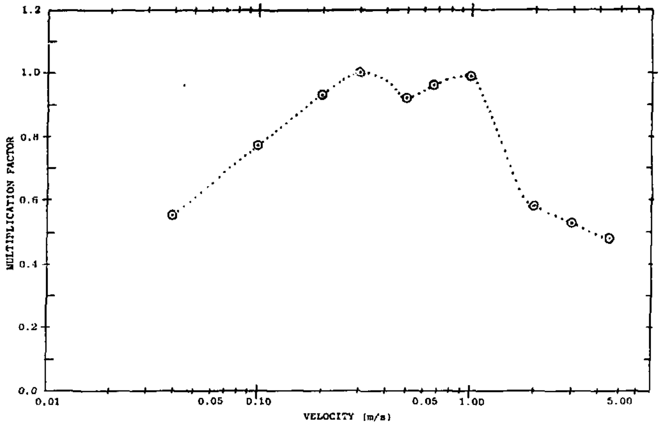


Figure 10. Johnson AG-1007-7 Velocity Effects

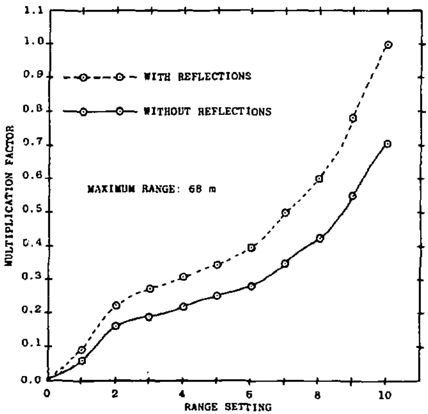


Figure 11. Johnson AG-1007-7 Range Setting Effects

This procedure is necessary since these curves were obtained with radial ($\phi = 0°$) walk-tests. As a result, all of the data are referenced to the intruder radial velocity component. This procedure assumes small integration times on the order of 1 second.

3.4 DETECTOR SENSITIVITY

The amplitude of the signal required to trigger the detector circuit can be adjusted by means of a potentiometer. This adjustment changes the bias voltage on the detector that must be overcome to cause an alarm. The detector sensitivity test was performed by setting the sensor to detect at 10 metres with the sensitivity on the factory setting. The sensitivity adjustment was then varied, and a walk-test was performed at each new setting. The effects of these adjustments are shown in Figure 12. All other tests were performed with the sensitivity adjusted to the factory setting.

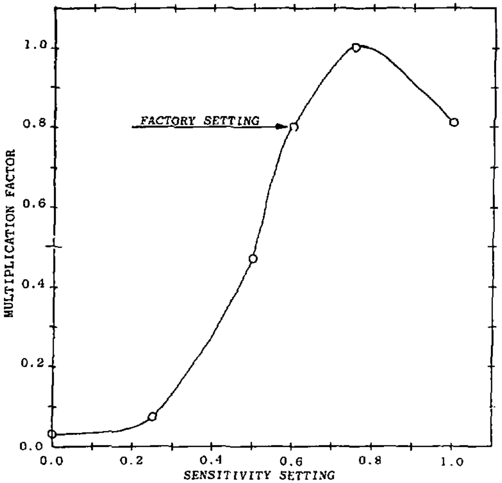


Figure 12. Johnson AG-1007-7 Detector Sensitivity Effects

3.5 TUNABLE OSCILLATOR

The Johnson AG-1007-7 has a tunable oscillator. This feature is desirable if more than one unit is used at an installation since it allows the operating frequencies to be selected so that cross-talk between units is minimized. Figure 13 shows the range over which the oscillator can be tuned.

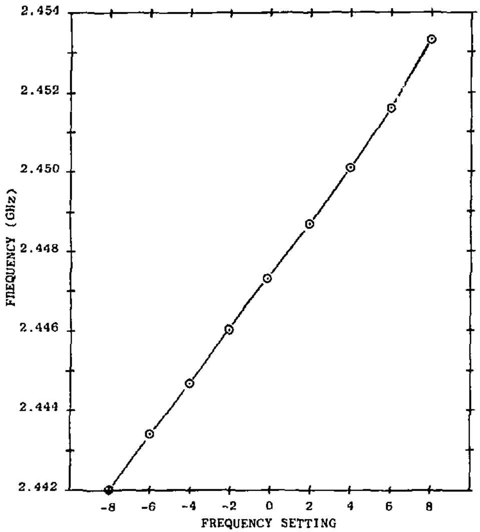


Figure 13. Johnson AG-1007-7 Frequency Setting

4. FALSE ALARM TESTS

4.1 OSCILLATORY MOTION TEST

The oscillatory motion test was performed to determine the susceptibility of the detector to oscillatory motion. The test was performed by a person standing at a distance of 2 metres in front of the sensor and rocking back and forth at a rate of once per second. The total distance rocked was approximately 5 to 7.6 cm. The range was set to detect at approximately 14 metres, and the preset factory setting was used for detector sensitivity. Under these conditions, the sensor immediately alarmed. The same test was repeated at a distance of 8 metres and 12 metres from the sensor. At these two distances, the distance rocked had to be increased slightly to initiate an alarm (approximately 15 to 20 cm at the 12-metre distance). This result reflects the fact that a greater motion is necessary to create a sufficient Doppler shift to overcome the detector bias voltage. There appears to be no provision on the Johnson AG-1007-7 for rejecting oscillatory motion; therefore, the unit would probably be quite susceptible to moving objects, e.g., drapes, hanging lights, etc., and to mount vibration. However, the sensor would be less susceptible to objects located some distance from the sensor.

4.2 FLUORESCENT LIGHT TEST

The detector was also tested for susceptibility to fluorescent light interference. The fluorescent light test was performed by placing the sensor at various radii from a fixture which contained two 40-watt fluorescent bulbs. The range of the sensor was set to detect at approximately 12 metres; the factory setting was used for detection sensitivity. The light was turned on and off at a rate of 1 cycle per second to simulate flickering. At 1 metre, the sensor alarmed each time the light came on; at 2 metres, the sensor alarmed after two or three cycles; while at 3 metres, the sensor only alarmed after two or three cycles if the sensor was pointed directly at the light. If the sensor was positioned to point at an area below the light, the flickering did not produce an alarm.

5. ENVIRONMENTAL TESTS

Environmental tests were performed at two temperature extremes, -15° C and 57° C and at three walk velocities: $V_1 = 0.05$ m/s, $V_2 = 0.3$ m/s, and $V_3 = 2$ m/s. The velocities were determined from the velocity effects curve (Figure 10). No standby battery was available for these tests. Table I shows the results of the environmental tests.

TABLE I

Environmental Test Results

Power Source (volts ac)	Temperature (°C)	Change in Radius of Detection (%)		
		V_1	V_2	V_3
93.5	57	--	-2	--
	-15	--	-6	--
110	57	- 1	-1	0
	-15	-11	-1	-2
120	57	--	0	--
	-15	--	-7	--

ATTACHMENT 1

Johnson AG-1007-7
Operation and Installation Manual

JOHNSON SERVICE COMPANY

507 EAST MICHIGAN STREET • MILWAUKEE, WISCONSIN 53201

TECHNICAL MANUAL
AG-1007-A

JOHNSON AG-1007

Solid-State Intrusion Detector

SECTION I: DESCRIPTION

The Johnson AG-1007 Intrusion Detector is an Underwriters' Laboratories, Inc. listed, self-contained solid-state interior space protection device. This unit detects the movement of an intruder in the area of protection and causes an SPDT alarm relay contact transfer when movement occurs.

The AG-1007 performs its function of intruder detection by transmitting a 2.45 GHz signal into the protected area and comparing the frequency of the transmitted signal with the frequency of the signal reflected back from the protected area. When movement occurs in the protected area, the 2.45 GHz signal is reflected back to the unit at a slightly different frequency as a result of the Doppler effect which occurs when the microwave energy is reflected off a moving object.

The 2.45 GHz microwave frequency, utilized by the AG-1007, is readily contained within the walls of the protected area. This makes alarm installations possible that are free from nuisance alarms, when prescribed installation procedures are followed.

Fig. 1: AG-1007-7

Fig. 2: AG-1007-8

The AG-1007 alarm circuitry discriminates against small moving objects, so that alarms are not caused by mice, insects, etc. The alarm circuitry is of the non-integrating type, that is, an alarm will be generated when two cycles of frequency shift occur and a fairly large amount of frequency shifted energy is reflected back to the receiver. This allows the unit to alarm quickly when an object the size of a man moves in the protected area and not to alarm from a series of small mass movements. The AG-1007 will detect very slow as well as very fast movements.

Specifications*

MODELS	AG-1007-7	INTRUSION DETECTOR WITH STANDARD ANTENNA (NET WT. 13 LBS.)
	AG-1007-8	AG-1007-7 IN KEY LOCKED 16 GA. STEEL CASE (NET WT. 17 LBS.)
RANGE (ADJUSTABLE)		100' × 40' WITH STANDARD ANTENNA
		80' × 40' WITH OPTIONAL SHORT RANGE ANTENNA
DETECTION CAPABILITY		1 FT./SEC. TO 22 FT./SEC.
TRANSMITTED FREQUENCY		2.45 GHz (S-BAND) ±8 MHz ADJUSTMENT
SUPPLY VOLTAGE		24 VOLTS (+10 TO -15%) 50/60 Hz (SEE T2-500-1 BELOW)
POWER CONSUMPTION		LESS THAN 10 VA
RF POWER OUTPUT		15 MILLIWATTS
AMBIENT TEMPERATURE LIMITS		32 TO 120F (0 TO 49C)
ACCESSORIES (ORDER SEPARATELY)	AG-1007-9	6-VOLT PLUG-IN REMOTE TEST MODULE (NET WT. 4 LBS.)
	AG-1007-12	12-VOLT PLUG-IN REMOTE TEST MODULE (NET WT. 4 LBS.)
	AG-1007-13	24-VOLT PLUG-IN REMOTE TEST MODULE (NET WT. 4 LBS.)
	AG-1007-6	SHORT RANGE ANTENNA (NET WT. 2 LBS.)
	EG-1002-1	"L" SHAPED ANGLE MOUNTING BRACKET (NET WT. 3 LBS.)
	EG-1002-2 OR -3	BALL JOINT (NET WT. 1.3 LBS.)
	VQ-6001-1	12-HR. STANDBY POWER SUPPLY (NET WT. 10 LBS.)
	VQ-6001-2	48-HR. STANDBY POWER SUPPLY (NET WT. 20 LBS.)
	VQ-6001-7	76-HR STANDBY POWER SUPPLY (NET WT. 40 LBS.)
	T2-500-1	120/24 V A.C. PLUG-IN TRANSFORMER (NET WT. 2 LBS.)

* All NET WT. listings are package shipping weights.

JOHNSON SERVICE COMPANY
507 EAST MICHIGAN STREET • MILWAUKEE, WISCONSIN 53201

SECTION I: (Cont'd)

The AG-1007 is self-supervising and contains a patented fail-safe circuit which causes a fail-safe relay to de-energize and cause an alarm if the unit becomes incapable of detecting motion. Operational stability of the unit is uneffected by a change in humidity, temperature, atmospheric pressure or other environmental conditions.

Remote testing of the AG-1007 is not required; however, plug-in remote test modules are available. A walk test light is provided on the face of the unit for testing and adjustment purposes.

An anti-jam circuit is included in the AG-1007 design that causes the unit to go into alarm if a modulated microwave source is introduced into the protected area in an effort to jam the unit. A case tamper switch is also provided to prevent tampering.

To meet government requirements or where specifications demand, the AG-1007-B unit is provided with a 16 gage, key locking, steel enclosure.

Interaction

To explain interaction and the reason for the tunable oscillator in the AG-1007, the Doppler effect must first be understood.

The Doppler effect is the apparent shift in frequency of sound or alternating electromagnetic energy caused by relative motion between the receiver and the energy transmitter. If the energy transmitter is moving toward the receiver, or the receiver toward the transmitter, the apparent frequency of the receiver energy is increased. If they are moving apart, the apparent frequency of the receiver energy is decreased.

In the case of the AG-1007, the unit transmits and receives from the same stationary point. The Doppler effect takes place when the reflector in front of the transmitted energy is moving. If the reflecting object is moving away from the receiver, there is an apparent frequency decrease in the receiver energy. If the reflecting object is moving toward the receiver, the opposite effect takes place. A stationary reflecting object will cause no frequency shift. The Doppler effect is used in any microwave motion detector as the method of detecting a moving object.

In the case of two or more microwave units that are being operated near each other (within 500 feet), the units could interact if their operating frequencies were less than 1 MHz apart. In a practical situation, if two units were operated, within the confines of an enclosed area, at a frequency of less than 1 MHz apart, the reflection of one unit's transmitted frequency might very well be received by the other unit, causing that unit to alarm. The solution to the problem of interaction is to maintain a separation between operating frequencies of greater than 1 MHz. The AG-1007 is furnished with a tunable oscillator which allows a 2 MHz frequency spacing to operate up to nine units with a 500-foot diameter area of separation.

SECTION II: THEORY OF OPERATION

As discussed, the AG-1007 Intrusion Detector utilizes the Doppler effect to detect a moving object.

Operation (Refer to Block Diagram Fig. 3)

D.C. power for the operation of all circuits in the AG-1007 is provided by an integral power supply. The D.C. output of the power supply is applied to two separate regulators, one for the transmitter and the other for the receiving circuits.

The output of the receiver regulator provides power for all of the receiving and signal processing circuits and for the modulator. The modulator output is applied to the transmitter regulator to modulate it slightly at a 1400 Hz rate.

When the output voltage of the transmitter regulator is applied to the microwave source, it produces an output frequency of 2.45 GHz. This 2.45 GHz signal is coupled into the transmitting antenna and transmitted into the protected area. The transmitter signal is continuous-wave, with a very small amount of amplitude modulation caused by the modulation of the voltage applied

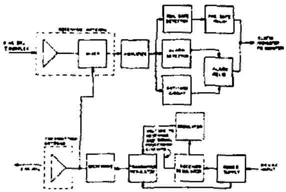


Fig. 3

to the microwave source. A small amount of the signal generated by the microwave source is coupled into the mixer for comparison with the signal reflected back from the protected area.

The 2.45 GHz signal from the transmitting antenna is somewhat directional and in effect "floods" the protected area with electromagnetic energy. Part of the transmitted signal is reflected back from the protected area to the AG-1007, and is picked up by the receiving antenna.

The received signal and the sample of the transmitted signal heterodyne or "beat" together in the mixer, a microwave diode. Present in the output of the mixer are the transmitted signal frequency, the received signal frequency, the sum of these two frequencies, and a frequency which is the difference between the frequency of the transmitted and received signals.

The higher frequencies (original and sum frequencies) are filtered from the output of the mixer, leaving the difference frequency. If motion occurs in the protected area, some of the signal transmitted into the protected area is reflected back from the moving object at a slightly different frequency. The frequency difference is present in the mixer output. If there is no motion in the protected area, the transmitted and received frequencies are the same and there is no output from the mixer. When a motion is detected, the difference frequency from the mixer is amplified to a high enough level to cause the alarm detector circuit to operate.

The alarm detector circuit holds the alarm relay energized until a motion signal of sufficient amplitude is applied to trigger the alarm detector. It then switches off the current through the alarm relay coil, causing the alarm relay to open its contacts, resulting in the transmission of an alarm indication.

The amplitude of the voltage required to trigger the alarm detector can be adjusted by changing the bias voltage on the alarm detector, thereby providing one means of adjusting the area coverage of the unit. The alarm detector is of the non-integrating type so that two cycles of the difference frequency signal are required to trigger it. The amplitude of the triggering signal must be great enough to overcome the bias voltage, so that small signals from mice, insects, background motion, etc. are effectively ignored by the detector unless they are within inches of the detector.

Because the voltage applied to the microwave source is modulated slightly, the continuous wave output of the source contains a very small amount of modulation. This modulation appears in the output of the mixer and is applied to the amplifier. Although it is outside the normal bandpass of the amplifier, the 1400 Hz modulation signal is amplified somewhat. However, it is not of sufficient amplitude to affect the alarm detector.

The presence of this modulation, or fail-safe signal, as it is normally called, is detected by the fail-safe detector circuit. As long as the signal is present, the detector holds the fail-safe relay energized. The signal is applied to the fail-safe detector only when the power supply and regulators, microwave source, mixer, and amplifier are operating. Failure of any of these circuits results in loss of the signal, causing the fail-safe relay to de-energize and give an alarm indication.

To preclude any possibility of jamming the AG-1007 by the introduction of an outside microwave source to the protected area, an anti-jam detector is included in the equipment. The anti-jam circuit detects the rise in the output of the amplifier and de-energizes the alarm relay if this output exceeds the normal level.

Switching the power to the oscillator is accomplished by means of a relay in the AG-1007. The relay may be operated by a switch located at the unit using the output of the D.C. power supply or by a remote switch using a separate power supply.

SECTION III: INSTALLATION

To successfully apply the AG-1007 Intrusion Detector in a security area it is necessary to understand the behavior of the energy radiated from the unit and to recognize the advantages and limitations of the equipment.

Operating on the Doppler principle, the AG-1007 transmits a microwave signal which is reflected back to the receiver by objects in the protected area. The detection circuits in the unit sense any frequency shift in the reflected signal caused by motion in the protected area. The unit gives an alarm indication when motion is sensed.

The AG-1007 operates at a microwave frequency of 2.45 GHz which is in the "S" band. The wave length is about 11.3 centimeters or 4.8 inches.

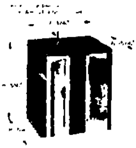
Behavior of Microwave Energy

Generally, as the frequency of radio waves becomes higher their behavior becomes more like that of light. They are more easily reflected by walls and partitions than energy of lower frequencies. Absorption of the microwave energy by wall materials (ie. concrete block, plaster, wood, etc.) is also generally greater at higher frequencies. Therefore, the "S" band energy is usually easier to contain than lower frequencies.

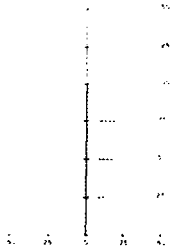
There is some reflection and absorption of the microwave energy by walls and other barriers. The surface finish (smoothness), composition and thickness of the barrier all have an effect on the amount of energy which is reflected, absorbed, or allowed to pass through the barrier. Metal is highly reflective and the most effective barrier to the microwave energy, allowing none to pass through even a very thin sheet. Wood, plastic, glass, and other nonmetallic materials allow radiation to pass, but they also reflect and absorb some of the energy. A sufficiently thick wall of nonmetallic material contains the energy enough to permit use of the microwave motion detector. Smooth walls are more reflective than walls with rough finishes.

Two different antennas are available for two specific areas of coverage: short range and intermediate range. Figure 4 shows the two patterns of coverage. Note: Underwriters' Laboratories listing applies only to the use of these two antennas.

The AG-1007 is normally mounted 8 to 12 feet above the floor. The unit is mounted on an EG-1002 bracket which facilitates positioning the unit to obtain the desired area of coverage.

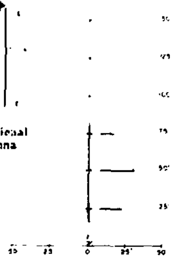


AG-1007-8 with Standard Intermediate Range Antenna



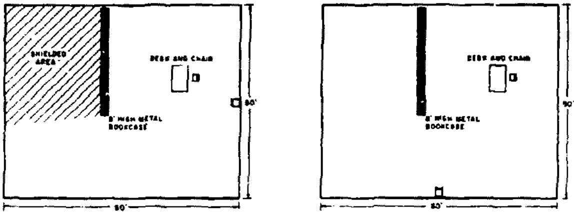
Intermediate Range Antenna Pattern

AG-1007-7 with Optional Short Range Antenna



Short Range Antenna Pattern

Fig. 4



Incorrect Location

Correct Location

Fig. 5

There are many situations where this type of motion detection equipment can be employed; only a few of these applications will be covered. The general methods of installation and the adjustment for the proper coverage to avoid nuisance alarms are explained in the following pages.

The number of AG-1007 units required and their specific location is determined by the size and shape of the area to be protected. Large fixtures and obstructions in the protected area must be carefully considered for their shielding effects. The units must be strategically located when full coverage is desired. Refer to Fig. 5 for a typical application of the AG-1007 unit in a shielded area.

Single Unit Installations

A typical room, 50 ft. by 50 ft., can be covered by a single AG-1007 unit with an optional short range antenna as shown in Fig. 6. The pattern of coverage, shown in Fig. 4, is broadened by reflections from the walls in this area to provide total room coverage. In small areas, the unit is installed in the center of the shortest wall and aimed at the opposite wall. In larger areas, a single unit can be used to cover the entire area by using the standard intermediate range antenna. Refer to Fig. 7 for single unit wiring.

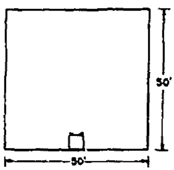


Fig. 6: Single Unit Installation

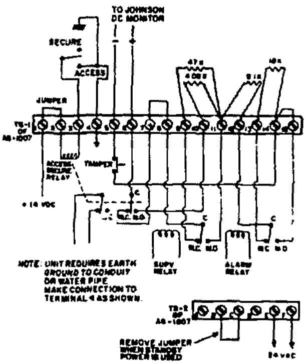


Fig. 7: Single Unit Wiring

SECTION III: (Cont'd)

Multiple Unit Installations

Very large or odd-shaped areas may require more than one AG-1007 unit to provide total room coverage, see Fig. 8. Both the length and the width of the area must be considered when planning multiple unit installations. Odd-shaped areas are more easily protected by selecting the proper antenna to provide the pattern of coverage necessary. In difficult areas, using an AG-1007 unit to check the area prior to final installation of the equipment is helpful in obtaining the desired coverage. Refer to Fig. 9 for multiple unit wiring.

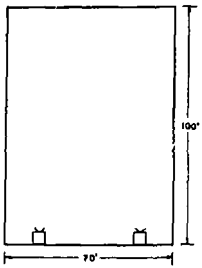


Fig. 8: Multiple Unit Installation

Nuisance Alarms

In addition to effectively protecting the security area, equipment must be set up in such a manner as to prevent nuisance alarms. Basically, this is accomplished by preventing movement of reflective objects inside the secured area during the hours of protection and by adjusting the range control to prevent detection of moving objects outside the protected area.

Some objects capable of causing nuisance alarms can be easily overlooked. The area should be carefully checked before the permanent installation is made. Listed here are several possible sources of nuisance alarms:

1. Walls, ceilings or floors that would tend to flex or bow as a result of normal environmental conditions or heavy traffic
2. Bats or birds flying immediately in front of the antenna
3. Large animals, such as dogs, in the protected area
4. Venetian blinds moved by the wind
5. Exposed electric fans or moving machinery (machines in metal cases cause no problems because the case shields the moving parts from radiation, unless of course, the case moves or vibrates)
6. Loose-fitting roll-type doors

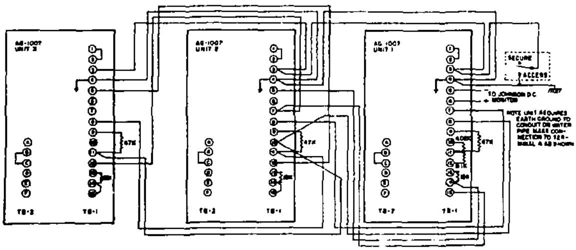


Fig. 9: Multiple Unit Wiring

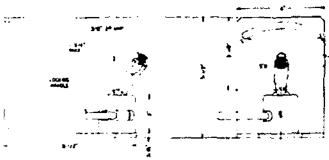


Fig. 10: EG-1002-2 Ball Joint Attached to EG-1002-1 "L" Shaped Angle Mounting Bracket

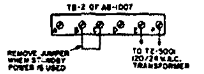


Fig. 11: AG-1007 Power Wiring

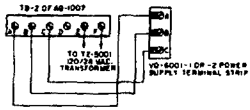
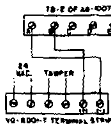


Fig. 12: AG-1007 Wiring to VQ-6001-1 or -2 (above) and to VQ-6001-7 (below)



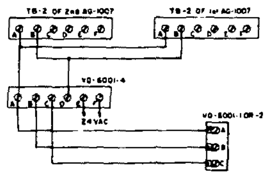


Fig. 13: Optional VQ-6001 Wiring to Two AG-1007 Units

7. Hanging fixtures, such as large light fixtures, swinging as a result of air motion
8. Moving duct covers or damper blades on the outside of air conditioning or heating ducts

The AG-1007 should be located so that it does not point directly at glass or thin wooden doors. These materials usually contain the radiation reflected from the room walls, but if the intrusion detector is aimed directly at the doors or glass, enough direct radiation may pass through to cause alarms from outside movements.

The range of the AG-1007 should be adjusted no higher than necessary to cover the protected area. In installations where there is doubt about alarms resulting from movement outside the protected area, the AG-1007 should be temporarily set up in the planned location and tested by walking outside the protected area. This can be accomplished while checking the coverage inside the area of protection.

Mounting

The bottom of the AG-1007 unit is designed to accept the threaded stem of the EG-1002 mounting bracket. Refer to Fig. 10 for bracket dimensions and installation.

Power Wiring

The required operating voltage for the AG-1007 is 24 volts at 50/60 Hz. The AG-1007 can be ordered with or without a TZ-5001, 120/24 volt A.C. plug-in transformer. The transformer is connected to TB-2 of the AG-1007 unit at terminals "E" and "F" as shown in Fig. 11. It is recommended that a standby power supply be used with each AG-1007 unit installed and mounted near the intrusion detector it supplies. Figure 12 shows the proper connections for wiring the AG-1007 to VQ-6001 Standby Power Supplies. Note: The AG-1007 unit requires an earth ground to terminal #4 of TB-1 (see Figs. 7 and 9).

Figure 13 shows an optional method of connecting two AG-1007 units to a single VQ-6001 power supply. A VQ-6001-4 adaptor must be ordered separately for proper operation. Note: The 24 volt A.C. transformer is connected directly to the adaptor when this arrangement is used. All power wiring must be in accordance with applicable electrical code requirements.

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SECTION III: (Cont'd)

Alarm Wiring—Monitors Other Than Johnson

Because of the large number of security monitors and control instruments presently available, no attempt is made here to show interconnection drawings for them all. Typical connections are shown in Figs. 14 and 15, to aid the installer in making up his own drawings.

Central Station Monitors: Figure 14 illustrates a typical wiring method which can be used for most conventional double drop central station monitors. This method provides constant supervision of the wiring through the AG-1007 and the tamper switches. A break and cross occurs when motion is sensed by the unit. Equipment failure, which causes the supervisory relay contacts to open, causes a break indication.

Local Alarms and Police Connection: Figure 15 illustrates a method which usually can be used with either police connected alarms or local alarms.

All alarm wiring must be in accordance with applicable electrical code requirements.

Remote Testing

AG-1007-9, -12, and -13 Remote Test Modules are solid-state electronic circuit boards designed for dynamic remote testing. They are equipped with female connectors that plug directly onto specific terminals on the detector alarm circuit board as shown in Fig. 16. The AG-1007-9 requires a 6 volt D.C. input, the AG-1007-12 requires a 12 volt D.C. input and the AG-1007-13 requires a 24 volt D.C. input.

When the proper voltage (6, 12 or 24 volts D.C. depending on the model selected) is applied to the test module input terminals, a signal is injected into the detector circuitry. This signal causes an alarm contact transfer and resultant alarm.

When the remote test contacts are located in the control unit in the protected area, the unit is wired as shown in Fig. 17. The wire size used for the input voltage is 18 AWG. The input power signal can be taken directly from terminals 1 and 4 of TB-1 on the detector. The distance between the control unit and the detector should not exceed 50 feet. Shielded wire should be used for these connections. Only the AG-1007-12 can be utilized in this application.

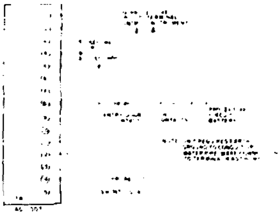


Fig. 15: Typical Local and Police Connected Alarm Wiring

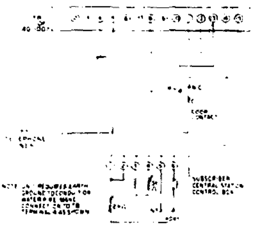


Fig. 14: Typical Central Station Alarm Wiring

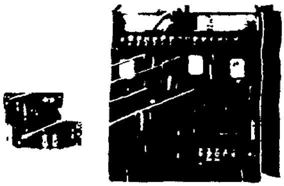


Fig. 16: Remote Test Module Location

If it is necessary that the remote test contacts be located greater than 50 feet from the detector, it is necessary to incorporate a separate power supply for the voltage input to the test module. This is necessary to prevent stray noise interference from triggering an alarm. The wire size is dictated by the wire length and the input voltage. Refer to Fig. 17 for a typical wiring diagram. Note: In all cases, proper polarity must be observed. All wiring must be in accordance with applicable electrical code requirements.

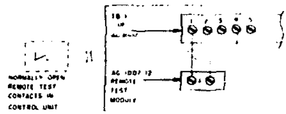
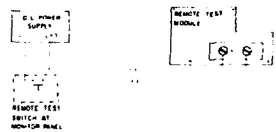


Fig. 17: Remote Test Module Wiring For AG-1007-12 (above) and AG-1007-9 and -13 (below)



SECTION IV: ADJUSTMENTS

After the detector is installed and the wiring completed, it must be adjusted for the proper coverage of the protected area as follows:

A Simpson 260 Multimeter (or equivalent 20,000 ohms per volt meter) is used in making the adjustments. Refer to Figs. 18 and 19 for locations of test points and controls. The case cover can be lifted off when the four screws in the bottom corners are removed.

Crystal Bias: With the detector in the "active" mode of operation, the multimeter is set up as follows; the negative lead to common and the positive lead plugged into the 50 microamp jack with the selector switch in the 50V (microamps) position. Measure the crystal bias voltage between TP1 (on the amplifier case) and ground. Do not stand in front of the antenna while making the adjustment. Body reflection affects the meter reading. The meter reading should be 70 ±15 mv. If the crystal bias voltage is outside

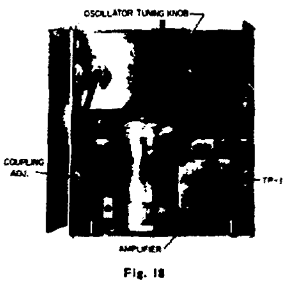


Fig. 18

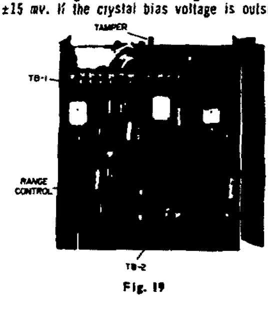


Fig. 19

SECTION IV: (Cont'd)

this mv. range, loosen the lower locknut on the coaxial cable fitting (coupling adjustment) on the receiver cavity and push the coaxial cable further into the cavity to increase the crystal bias or pull out the cable slightly to decrease the crystal bias as required. When the correct bias voltage is obtained, retighten the locknut.

Range Control: Adjust the range control to give the desired coverage. The coverage can be determined by walk testing. As an aid when walk testing, a walk test light has been added to the front of the AG-1007. It is also equipped with an opaque lens cover to conceal the light when the unit is in operation. The walk test light is normally off, and is energized when the unit detects motion. This light can be used to check an area of coverage, and for periodic operational checks by the subscriber. **The range control must be set to cover the area desired, and not greater. Settings which are too high, increase the possibility of nuisance alarms.**

Tunable Oscillator

In multiple unit installations, each AG-1007 unit should be adjusted to operate a minimum of 2 MHz apart from each other. This frequency spacing should be the maximum possible. Thus, if you have two units in the same area, one setting should be fully clockwise, the other fully counterclockwise. With a three unit installation, one oscillator setting should be fully clockwise, one centered, and one fully counterclockwise. The markings on the end of the oscillator are about 2 MHz apart.

As with any security device, the AG-1007 requires periodic maintenance. It is recommended that these adjustments and the coverage of the unit be checked semi-annually, at a minimum. In extremely dusty or hostile environments these adjustments should be checked on a quarterly basis.

With all adjustments made and the unit properly aimed, installation is complete.

SECTION V: TROUBLESHOOTING

Motion detector units and monitors should be returned to the Electronics Division in Dallas for any major repairs. Minor repairs which can be accomplished quickly, such as fuses and crystals, can be performed in the field. If the unit fails to operate properly, the following checks will aid in determining the condition of the equipment and the location of troubles.

Crystal Mixer (Receiver)

Place the access-secure switch in the access position. Remove the amplifier plug from the amplifier. Measure the resistance across the receiver output cable with the meter on the R x 100 scale (See Fig. 18). Reverse meter leads and repeat. Forward resistance should be approximately 200 to 400 ohms. Back resistance should be approximately 50 to 100K ohms. If these readings are close to the values given, the crystal has a satisfactory front-to-back ratio.

Crystals, even though they check out satisfactorily using the ohmmeter test given, may be what is termed "noisy". A noisy crystal can cause false alarms, particularly if the unit is set up for large area coverage or long range. Another symptom of a noisy crystal may indicate an excessively high supervisory signal level. If all voltages check properly as outlined above, the crystal voltage is between 55 and 85 mv. and false alarms or insensitivity are observed with the unit, the crystal should be replaced. Any time the crystal is replaced, readjustment of the AG-1007 controls will probably be required. Also, before a final determination is made to replace the crystal, the protected area should be checked for any moving objects in the area, such as fans, or for large vibrating objects, such as air conditioning duct work, or possibly swaying light fixtures, doors and windows being moved by wind, etc.

To remove the crystal for replacement, remove the two screws which secure the amplifier (Fig. 18) to the unit, and lift the amplifier from the waveguide.

CAUTION: When removing the crystal, a pair of insulated pliers should be used or when removing by hand, one hand should be grounded to the exterior of the case. If this is not complied with, the electro-static charge developed in the body will be discharged through the crystal and render the crystal useless.

Once the amplifier has been removed, the crystal and integral RF bypass capacitor are removeable. Separate the crystal from the RF bypass capacitor and replace in the reverse order of removal.

NOTE: Keep spare crystals in their protective foil containers. When handling crystals, pick up both ends simultaneously. Crystal can be destroyed by stray electrostatic charges.

When the equipment is properly adjusted and in the "Active" condition, failure of the supervisory relay to pull in indicates trouble in the amplifier or detection circuitry, if the rest of the circuits check out satisfactorily. Units with troubles in the amplifier or detection circuits should be returned to the Electronics Division for repair.

NOTE: Very strong motion signals can cause the fail-safe relay to drop out, due to the amplifier being saturated. This is normal and should not be considered a problem.

Relays

Relay contacts may require cleaning after a year or more of operation. A piece of slick paper can be used to clean the contacts.

It is a good practice to make sure all adjustments are properly set before concluding that equipment is faulty.

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