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Police Traffic Radar

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HIGHLIGHTS

- The role of police traffic radar in traffic safety enforcement continues to be of critical importance, especially in view of the safety and fuel conservation benefits of the 55 mph speed limit and the requirement that all States must meet uniform national 55 mph compliance criteria enacted by the Congress. Police traffic radar provides a means of increasing enforcement effectiveness and thus enables police administrators to better cope with the scarcity of manpower resources and rapidly increasing fuel costs.

- This report describes recent developments, and discusses activities sponsored by the National Highway Traffic Safety Administration. We have entered into an interagency agreement with the National Bureau of Standards (NBS) to develop performance standards for police speed measuring devices and we are developing a model training program for police officers in the use of speed measuring devices. We believe the products which will result from each of these efforts will help States to upgrade both the reliability and quality of police traffic radar equipment and the quality of operator training.

- Also included in this report are the initial results of special tests conducted by the NBS on police traffic radar equipment questioned in a Judicial Hearing in Dade County, Florida. As a result of the decision rendered by the Eleventh Judicial Court of Florida, NHTSA asked NBS to conduct a series of special tests as part of the on-going joint NBS/NHTSA project to develop performance standards for various police speed measuring devices, including radar.

- The NBS researchers were particularly concerned with the susceptibility of the radar devices to interference from CB and police radios, police cars' ignition, alternator, and air-conditioner and heater fans. The researchers also examined phenomena such as: patrol speed shadowing, target speed bumping or batching, and possible errors due to panning, scanning, interpreting the cosine angle effect, and the automatic lock-on feature. NBS concluded, based on tests of the six devices identified in the Dade County hearing, that police radar which measures vehicle speeds is a reliable tool for police use when carefully installed and properly operated by skilled and knowledgeable operators.

- This report asserts that radar is a reliable tool when properly installed and operated by skilled and knowledgeable operators. However, we recommend that States develop a comprehensive statewide program to establish uniform statewide standards, guidelines and procedures for: operator training and certification; equipment purchase, maintenance, testing and certification; operating practices; and periodic recertification of both equipment and operators. We believe that adoption of these basic measures should enable police agencies to more effectively respond to the challenges to traffic radar use which were raised by the Dade County Hearing.

POLICE TRAFFIC RADAR: IS IT RELIABLE?

Background:

The use of police traffic radar has become widespread throughout the United States and, until recently, was widely accepted by the courts and the general public as a reliable and accurate means of measuring vehicle speeds. However, recent technological advances, especially the development of "moving radar," have altered the basic concepts initially accepted by the courts. These technical innovations have resulted in increased and highly publicized challenges to both the reliability and accuracy of modern traffic radar devices and the adequacy of police radar operator training.

Discussion:

Police traffic radar has been used to detect speeding motorists for about 30 years in this country. During that time radar speed measuring devices have evolved from the original bulky stationary models to the present compact and sophisticated models capable of monitoring vehicle speeds in both stationary and moving modes. These technological advances have greatly enhanced the mobility, efficiency and effectiveness of police traffic radar operations. However, highway safety and traffic law enforcement officials are now faced with a dilemma since the same technological advances that enable increased productivity and efficiency have resulted in increased scrutiny by the courts. In addition, the public is now beginning to question both the reliability and accuracy of radar devices and the adequacy of police radar operator training.

At the present time there are no nationally recognized performance standards for police traffic radar speed measuring devices. Further, operator training requirements, which have traditionally been established by each individual police agency (usually with the assistance of the radar manufacturer), range from less than one hour to several days. The quality of operator training often has not kept up with the technological advances. In many cases, training has been limited to teaching the officer how to set up, test and operate the device. All too often, failure to provide detailed training in recognizing and avoiding the electronic anomalies associated with modern traffic radar devices has led police officers to believe that radar devices are infallible.

A highly publicized Dade County, Florida evidentiary hearing regarding the reliability and accuracy of radar illustrates the type of challenge now being encountered. The hearing, conducted by Judge Alfred Nesbitt in April 1979, focused on two issues. First, whether radar speed measuring devices currently produced are reliable enough to be used as evidence; and second, whether police officers are receiving adequate training in the proper operation of the devices. After nine days of testimony, during which experts from both sides were invited to give testimony, Judge Nesbitt ruled:

> ... that the reliability of the radar speed measuring devices as used in their present modes and particularly in these cases, has not been established beyond and to the exclusion of every reasonable doubt ... .

While the Dade County hearing has not triggered the predicted nationwide demise of police traffic radar, it has highlighted the fact that in certain circumstances radar does have its limitations. Subsequent court decisions such as State of New Jersey vs. Wojtkowiak and State of Hawaii vs. Earl W. Fedje, et al., generally have upheld the reliability and accuracy of police traffic radar. However, the message from the courts is clear: highway safety and law enforcement administrators must ensure that radar operators receive adequate training, including recognition and avoidance of the electronic anomalies associated with such devices. Operators must be able to demonstrate their competence with the unit under varying conditions in supervised field performance tests. In addition, the radar manufacturing industry must implement strict quality control measures to ensure the reliability and accuracy of their equipment, and continue to search for ways to improve the target identification capabilities of present radar devices.

The courts, as well as some radar critics, also have pointed out the need for State-level policy guidance for police radar enforcement programs. The immediate reaction to such criticism tends to be defensive. Perhaps this is an appropriate time to review radar programs from a constructive viewpoint. After evaluation of present programs, highway safety and law enforcement officials should develop and implement comprehensive policies and procedures to ensure that police traffic radar is used properly and that traffic safety and energy conservation goals are achieved. State-level policy guidance would provide the added benefit of increased uniformity within a State and encourage statewide development of standard operating procedures. This would enhance voluntary compliance as the motorist travels through the many jurisdictions within each State.

The National Highway Traffic Safety Administration (NHTSA) is sponsoring two programs which should upgrade both the reliability and credibility of police traffic radar equipment and the quality of operator training.

Equipment:

In August 1977, before many of the above issues were raised publicly, we entered into an interagency agreement with the National Bureau of Standards (NBS) in the Department of Commerce to develop performance standards for police speed measuring devices. The NBS has inventoried all police speed measuring devices (radar and nonradar) used in this country and is in the process of developing comprehensive performance standards for each speed measuring device category. The performance standards for radar devices should be completed by June 1980. Once the standards are established, NBS will coordinate the testing of existing devices and compile a list of those devices meeting the standards. This qualified products list will be published in the Federal Register.

The qualified products list will aid police administrators in making more informed purchasing decisions. Moreover, the list will identify those specific models which can be purchased by State and local law enforcement agencies with Federal highway safety funds.

In addition, we asked NBS to conduct special performance tests on the six radar devices identified in the Dade County hearing. The purpose of this project was to test each of the six radar units to observe their operational capability in certain operating situations or environments that were described in the hearing. The preliminary test results confirm that the six devices produced reliable and accurate speed measurements. However, NBS also determined that there are certain operational situations which may lead an inattentive or untrained operator to obtain an inaccurate reading or to associate the speed indicated on the radar device with the wrong vehicle. NBS also points out the potential for obtaining an erroneous reading on a target vehicle under certain conditions when the radar unit is operated in the moving mode. Judgemental errors may occur if police radar operators do not understand and avoid the specific circumstances which give rise to these anomalies.

It is also clear that police administrators must ensure that radar devices are properly maintained and periodically tested and calibrated. Written policy defining maintenance and calibration procedures should be established in each agency. The procedures should define the conditions under which each device should be calibrated by a licensed technician. As a minimum, we recommend that each radar unit be tested for measurement accuracy annually. The written policy should specify that accurate maintenance, repair and calibration records for each device should be established and maintained by the agency. These records should be available to the courts, whenever necessary, to verify the accuracy of the device.

Training:

In September 1978, we awarded a contract for development of a model training program for police officers in the use of speed measurement devices. The training program has two elements, one covering radar speed measuring devices and one covering nonradar devices. The overall goal of the training program is to improve the effectiveness of speed enforcement through the proper and efficient use of speed measurement devices. The specific objectives of the radar course are to develop and/or improve the trainee's ability to:

- Describe the association between excessive speed and accidents, deaths and injuries and describe the highway safety benefits of effective speed control
- Describe the basic principles of radar speed measurement
- Acquire and demonstrate basic skills in testing and operating the specific radar instruments
- Identify the specific radar instrument(s) used by the trainee's agency and describe the instruments major components and their functions

- o Identify and describe the laws, court rulings, regulations, policies and procedures affecting radar speed measurement and speed enforcement in general

- o Acquire and demonstrate basic skills in preparing and presenting records and courtroom testimony relating to radar speed measurement and enforcement

The radar training course is designed in a modular format to provide maximum flexibility for the user. It is comprised of eight units, each of which has specific performance objectives. The formal classroom training comprises a block of 24 instruction hours. Upon successful completion of a written exam, the trainee must undergo a minimum of 16 instruction hours of supervised field practice. After completing the course of instruction, the trainee must be able to demonstrate his operational (real world) competency before being certified to take enforcement action based on radar speed evidence. Recertification of all operators should occur within not less than one nor more than three years.

Although this course focuses on enforcement and is intended primarily for the police patrol officer, we recommend participation in the training program by traffic adjudication personnel, e.g., judges, administrative hearing officers, prosecutors, etc. Such personnel routinely decide upon the admissibility and weight of radar speed evidence, the strengths and weaknesses of the instruments and the capabilities and limitations of the operators. This type of training will provide adjudication personnel with a good working knowledge of radar speed measurement principles and an understanding of the issues relevant to judicial deliberations.

Position:

The National Highway Traffic Safety Administration believes that police traffic radar is an effective enforcement tool. The role of police traffic radar in traffic safety enforcement continues to be of critical importance, especially in view of the safety and fuel conservation benefits of the 55 mph speed limit and the requirement that all States must meet uniform national compliance criteria enacted by Congress. Police traffic radar provides a means of increasing enforcement effectiveness and thus enables police administrators to better cope with the scarcity of manpower resources and rapidly increasing fuel costs.

Highway safety and law enforcement officials should recognize the fallacy of purchasing radar devices solely on the basis of economy without due regard to their performance capabilities. These officials must also recognize the importance of greatly improved operator training and State-level policy guidance to ensure high quality and more uniform police radar operations throughout a State. Inaction on these issues by State and local highway safety and law enforcement officials may well result in judicial limitations governing the use of police traffic radar.

It is essential that each State develop a comprehensive radar speed enforcement program which, as a minimum, embraces equipment standards, operator training, operator certification, and policy/procedural guidance. Accordingly, each State is strongly urged to:

- o Adopt the forthcoming NBS/NHTSA radar speed measuring device performance standards and require police agencies to purchase devices meeting those standards

- o Develop policy guidelines to ensure that radar speed measuring devices receive proper care and upkeep and establish clear procedures for programmed maintenance, testing, and calibration

- o Ensure that adequate maintenance and calibration record systems (suitable for introduction as evidence in court) are developed and maintained by each agency using radar speed measuring devices

- o Adopt the NHTSA radar operator training program or its equivalent as the statewide minimum training standard

- o Develop a comprehensive State-level radar operator certification program and provide for periodic recertification (every 1-3 years)

- o Develop police radar workshops and seminars for traffic adjudication personnel

- o Establish State-level policy/procedural guidelines to ensure proper use of police traffic radar in meeting traffic safety and energy conservation goals and objectives.

Implementation of these minimal measures should result in significantly improved and more uniform radar speed enforcement programs both within the individual States and nationwide. Their implementation is necessary to establish a sound legal foundation for radar speed evidence and to restore public and judicial confidence in radar enforcement programs.

TESTS OF SIX
SPEED MEASURING RADAR UNITS

INTERIM REPORT

Submitted to

National Highway Traffic Safety Administration
Department of Transportation
Office of Driver and Pedestrian Research
Washington, DC 20530

Submitted by

Law Enforcement Standards Laboratory
National Bureau of Standards
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EXECUTIVE SUMMARY

Each of the six radar models identified in hearings conducted by the Eleventh Judicial Circuit Court of Florida were subjected to a series of laboratory and field tests.

The tests were designed to determine whether it was possible to affect target speed measurement under those environments or use situations discussed in the Florida hearing.

There was no observed degradation in the performance of any of the units arising from 1) cosine angle effect, 2) automatic lock, 3) heat build up, 4) mirror switch aiming, and 5) high tension power wire interference. Only one of the six units tested was affected by external CB and none were affected by police radio transmission at distances beyond 30 feet from the radar.

Certain of the units were affected in varying degrees by internal electrical interference from the ignition and alternator, and interference from air conditioner and heater fans. While transmission from police radios in the same vehicle as the radar was found to have a limited affect on the radar units, CB transmission in the same vehicle affected nearly all radars.

Patrol car shadowing was found to affect all but one of the radars and target speed bumping was observed to effect half of the units. In all cases, the two piece radars were affected by panning the antenna beam through the display console.

In some instances, the performance of the radar units was not degraded by the environments or use situations described above when a target vehicle was present.

The limited sample size precludes generalization of the test results to an entire manufacturer product line. While there is no question that the individual radar units that were tested are affected to varying degrees by interference sources and certain operating conditions, it appears, based upon observation, that the source of error can be avoided by taking precautions in the installation of the radar unit and through proper use by a skilled and knowledgeable operator.

I. INTRODUCTION

This report presents the results of a series of laboratory and field tests that were conducted by the National Bureau of Standards, Law Enforcement Standards Laboratory (LESL) to evaluate the performance of six specific speed measuring radar units under a variety of operational and environmental conditions.

The testing was accomplished at the request of the National Highway Traffic Safety Administration (NHTSA) as a special project, Modification Number 8, of the ongoing effort to develop performance standards for speed measuring radar units under Interagency Agreement DOT-HS-7-01697. The radar units that were tested are those identified in the hearing conducted by the Eleventh Judicial Circuit Court of Florida; the CMI Speedgun 6 and Speedgun 8, the Decatur Electronics MV-715, the Kustom Signals MR-7 and MR-9, and the MPH Industries K-55.

The data presented in this report may or may not be representative of a particular radar model since the testing was limited to only one or two units of each model. Moreover, because of this limitation and the nature of the field test portion of this study effort, the data cannot be used to compare any one model with any of the others being tested.

II. PURPOSE

The purpose of this project was to test each of the six models of speed measuring radar units to observe their operational capability in certain operating situations or environments that were described in the Florida hearing: shadowing, batching (target speed bumping), panning error, scanning error, cosine error and errors due to automatic lock-on feature, heat buildup, power surge, mirror switch aiming, external interference, and internal automobile interference. The secondary purpose of this testing program was to collect data concerning several basic attributes of the radar units for use in the later development of performance standards.

III. PROCEDURE

A brief description of each test procedure used during this project is presented in appendix A. These are presented for overview purposes only, and do not contain sufficient detail to enable the tests to be duplicated by other laboratories.

Each speed measuring radar unit, as received, was subjected to a series of laboratory tests to determine whether the unit conformed to the manufacturer specifications and FCC requirements for such equipment. The microwave radiated beam width and radar microwave oscillator frequency were measured. These same measurements were then repeated to determine the effects of high and low temperature and battery supply voltage variation. In addition, the frequency of the tuning fork provided with the unit for calibration of the device was also measured. These data were collected for the purposes of performance standard development, and while reported in appendix A, are not discussed in detail.

The frequency-to-speed conversion of each speed measuring radar unit, and the POWER-ON and STANDBY-ON (Kill or Hold switch) stray reading tests were also performed in the laboratory using the test methods described in appendix A. The results of these tests are presented in the next section of the report.

The remaining tests were accomplished with each speed measuring radar unit installed in a four door sedan, typical of the type of automobiles currently used as police vehicles (in this case, a Matador), and in a pickup truck, or in a Pinto. A series of tests described in appendix A were conducted to determine the presence of interference from the vehicle alternator and ignition, and from the vehicle air conditioner/heater fan. The interference from five watt citizen band radios and 100 watt police radios was observed by operating such radios installed in the vehicle with the radar unit operating, and with such radios installed in separate vehicles that were driven toward the patrol car to determine the distance between vehicles at which any interference with the radar was observed. In addition, a two watt handheld portable FM radio was operated in the patrol car with the radar unit operating.

The remaining tests were conducted on two field sites; a straight stretch of open two lane highway 1.8 miles long (Highway 52), and a similar secondary road (LOKOT) that was paralleled by high tension wires. Each radar was installed in the standard four door sedan in a position recommended by the manufacturer and the range of the radar was measured using three different target vehicles; a compact automobile, a standard size sedan and a recreation vehicle. Road tests also included observations of shadowing, batching, cosine angle effect, mirror switch aiming and high tension wire interference. These data are discussed in the section of this report that follows.

IV. TEST RESULTS

The results of the testing that was accomplished during this project are summarized in table 1. In this table, and in reporting all test results, each specific radar unit has been coded with an arbitrary designation of A, B, C, D, E, F, or G. The test results for each operational situation or environment as identified in the Florida hearing are presented separately in the paragraphs that follow.

o <u>Shadowing</u>

Shadowing, better identified as patrol speed shadowing, is the tendency of a moving mode radar to use a slow moving large vehicle rather than the ground to measure the speed of the patrol car. The patrol speed shadowing test is described in test 16. This effect was observed, in varying degrees, for several of the radars during testing.

<u>Radar Unit A</u>: Patrol speed reading went from an actual 26 mph to indicated 22 mph as large oil tanker passed patrol car. No other effects from large trucks were observed.

<u>Radar Unit B</u>: Large truck came to a stop 50 yards in front of patrol car and the patrol car reading changed from 40 to 28 mph. Several large trucks traveling in front of patrol car and trucks passing patrol car had no effect on readings.

<u>Radar Unit C</u>: Actual patrol speed of 25 reduced to 17 when following a large truck. Actual patrol speed of 34 reduced to 11 mph for a long time when a pickup truck passed the patrol car. Pickup passing patrol car decreased patrol speed reading by 10 mph and increased target speed reading by 10 mph.

<u>Radar Unit D</u>: This particular unit demonstrated very severe shadowing effects from moving vehicles in the vicinity of the radar. A 44 mph patrol speed momentarily dropped to 11 mph with a pickup truck 100 feet in front of patrol car. While traveling at actual patrol speeds of 30 to 40 mph and target speeds of 50 to 60 mph, the following readings were observed as the patrol car was passed by trucks.

Patrol	Target
12	80
16	72
20	57
17	68

This unit shadowed most trucks, large or small.

Table 1. Summary of test results.

Test	Radar unit A	B	C	D	E	F	G
1. Patrol car shadowing	Slight	Slight	-	-	-	-	+
2. Target speed bumping	+	Slight	+	-	+	Slight	+
3. Panning error	-	-	-	N/A	N/A	-	-
4. *Scanning error	+	-	-	-	-	-	+
5. Cosine angle effect	See text						
6. Automatic lock	See text						
7. Heat build up	+	+	+	+	+	+	+
8. Power surge							
a. Power-on	-	-	+	+	+	-	+
b. Kill switch	N/A	N/A	+	N/A	+	+	N/A
9. Mirror switch aiming	See text						
10. External interference	See text						
a. High tension wires							
b. CB radio	+	+	+	+	+	-	+
c. Police radio	25 ft**	20 ft**	+	+	+	30 ft**	+
11. Internal interference							
a. Ignition and alternator	+	+	-	Slight	+	+	+
b. *Air conditioner and heater fans	+	-	-	-	-	+	+
c. CB radio	-	-	-	-	+		-
d. Police radio							
(1) 100 watt mobile	Blank	Blank	+	Slight	Blank	Blank	-
(2) 2 watt handheld	Blank	Blank	+	+	Slight	Blank	Blank

*No effect when bonafide target was present.
**Interference was detected out to this distance.

Notes:
+ - Radar performance unaffected.
- - Negative effect on radar performance.
Slight - Occasional slight effect on radar performance.
N/A - Not applicable. Test could not be performed.
Blank - Display went blank because of interference.

Radar Unit E: While traveling at patrol speed of 50 mph, shadowing from passing large trucks caused radar readings of:

Patrol	Target
17	74
11	41

This effect did not occur every time a truck passed. Patrol readings decreased momentarily several times when a passenger sedan passed patrol car.

Radar Unit F: While the patrol car was traveling 35 mph, readings of 20 patrol and 76 target were observed. Then a pickup passed the patrol car and pulled back into the lane. Actual patrol speed of 47 mph dropped to 35 mph as a large truck passed patrol car. This happened about 20 percent of the time that trucks passed.

Radar Unit G: No effects on target readings or patrol speed readings of shadowing from passing large trucks were detected.

- Batching

Batching, better identified as target speed bumping, occurs if the target vehicle speed display varies when the patrol car changes speed. The target speed bumping test is test 17. This effect was observed for some of the radars during testing.

Radar Unit A: No effect on target speed readout due to acceleration or deceleration of patrol car.

Radar Unit B: Radar occasionally subtracted 2 to 3 mph from target reading when patrol car was accelerated. This was not consistent. No effect on deceleration.

Radar Unit C: Accelerating or decelerating patrol car had no effect on target readings.

Radar Unit D: Radar target speeds decreased with both acceleration and deceleration. Target speed decreased 3 mph when patrol speed suddenly increased. Target speed decreased 5 mph when patrol speed suddenly decreased.

Radar Unit E: No effect on target speed reading could be observed from accelerating or decelerating patrol car.

Radar Unit F: On rare occasions target speed readings increased 2 or 3 mph when speed of patrol car was increased or decreased. Mostly no effect.

Radar Unit G: No effect observed on target readings from sudden increase or decrease of patrol car speed.

- Panning Error

Panning error occurs when the radar antenna is used to pan through its own display. The two one-piece units cannot do this. Using the radar in this fashion always produced an erroneous reading. The panning error test is test number 13.

Radar Unit A: Panning antenna across radar readout console produced 101 mph readings.

Radar Unit B: Panning antenna across radar readout console produced 75 mph readings.

Radar Unit C: Panning antenna across radar readout console caused readings over 100 mph.

Radar Unit D: NA.

Radar Unit E: NA.

Radar Unit F: Panning antenna across radar readout console produced various readings.

Radar Unit G: Panning antenna across radar readout console produced 95 mph readings.

- Scanning Error

Scanning errors can result when the radar operator moves his antenna too quickly. The results obtained from testing by positioning the radar in commonly used positions and/or pointing in several directions are discussed below. The air conditioner/heater fan interference test is test 13. Although erroneous readings were observed for some of the radars during these tests, this interference was not observed when the radars were tracking a target during operational testing.

Radar Unit A: No effect from AC/heater fan motor or AC/heater fans when pointed any direction inside car.

Radar Unit B: Picked up AC/heater fan intermittently while mounted on dash. When heater fans were on, scanning dash with handheld antenna caused readings proportional to fan speed. No readings from fans when antenna was pointed out the side windows. Picked up fan readings when radar was pointed out rear window (radar held above back of front seat cushion).

Radar Unit C: When mounted, antenna pointed slightly downward towards dash with heater fans on high: Stationary Mode--Target 52; Moving Mode--Target 34, patrol 55. No readings from fans when antenna pointed out the side or rear windows. Antenna mounted outside rear passenger window slightly aimed at dash with fans on, picked up readings 24 to 52 mph in stationary mode.

Radar Unit D: Handheld radar pointed at dash, picked up AC/heater fans. No effect from fans, no readings when pointed out the side or rear windows.

Radar Unit E: Handheld radar antenna pointed at dash picked up readings from AC/heater fans. This unit seemed to pick up the fans extremely easy when antenna was aimed forward but not mounted on dash mount. No readings when antenna was aimed out the side or rear windows.

Radar Unit F: No fan readings when unit was dash mounted. When radar antenna is pointed at dash, radar picks up fan readings. No speed readings when antenna is pointed out the side or rear windows.

Radar Unit G: Scanning dash with radar antenna did not pick up AC/heater fans. No readings when antenna was pointed out the side or rear windows with all fans on.

- Cosine Angle Effect

The cosine error, better named cosine angle effect, was closely observed during the testing for this effect is present any time that the radar and the target vehicle are not heading directly toward each other. The speed the radar displays when in the stationary mode, is equal to the actual speed times the cosine of the angle between the direction of travel of the target vehicle and the radius vector from the radar to the target vehicle. Radar training manuals advise radar operators not to use radars where the direction of travel is greater than 12 degrees from the center of the radar beam. Twelve degrees produces a 2.2 percent reduction in the speed displayed. When operating in the moving mode and assuming center beam tracking, the radar has the same cosine angle effect in the patrol speed reading as in the target speed reading. The cosine angle effect was not the subject of a separate test, but was instead observed during field testing. No erroneous readings were noted during these tests due to the cosine angle effect.

o Automatic Lock

The advantages and disadvantages of the automatic lock feature were also observed. The advantage is in enabling the officer to automatically obtain a speed on the display console using a present threshold value. The disadvantages far outweigh this advantage. The primary one is that it prevents the radar operator from obtaining a tracking history, i.e., what the vehicle being tracked does after it is detected traveling over the speed limit. Also, the radar may automatically lock-on to a stray abnormal reading which only appeared momentarily due to an unobserved interference source. Another disadvantage is that use of the automatic lock feature makes it almost impossible to compare the patrol car speed with its radar measured counterpart to insure that the two agree at the time the display is locked in or at times of possible interference such as that brought on by patrol speed shadowing. Again, there was no separate test to observe the use of the automatic lock feature. Instead, its use was evaluated during the field tests.

o Heat Buildup

None of the radar units were significantly affected by heat buildup, as tested by exposure to high temperatures. For example, the worst condition which eas experienced by test radar unit D, produced a change in speed of only 0.019 miles per hour.

Radar Unit A: At a temperature of 60°C, the microwave frequency changed from 10522.1 to 10516.3 MHz and the radiated power, 85 mW was unchanged.

Radar Unit B: At a temperature of 60°C, the microwave frequency changed from 10533.1 to 10523.7 MHz and the radiated power, 134 mW, was unchanged.

Radar Unit C: At a temperature of 60°C, the microwave frequency changed from 10520.6 to 10516.2 MHz and the radiated power, 120 mW, was unchanged.

Radar Unit D: At a temperature of 60°C, the microwave frequency changed from 10539.1 to 10519.3 MHz and the radiated power 34.25 mW, was down 0.6 dB.

Radar Unit E: At a temperature of 60°C, the microwave frequency changed from 10544.5 to 10541.6 MHz and the radiated power, 39.2 mW, was down 0.2 dB.

Radar Unit F: At a temperature of 60°C, the microwave frequency changed from 10550.9 to 10546.2 MHz and the radiated power, 26.3 mW, was down 0.3 dB.

Radar Unit G: At a temperature of 60°C, the microwave frequency changed from 10512.1 to 10513.0 MHz and the radiated power, 56 mW, was unchanged.

o Power Surge

The power surge that occurs when the radar unit is first switched on or when a HOLD or KILL SWITCH is activated did not affect any of the six types of radar. The hold or kill switch is a device that is used to inhibit, or "kill", radar transmissions, usually for the purpose of identifying a specific target at a range well within the radar capability. The use of this switch allows the radar to be operational and "ready to go" but not actually transmitting. No false readings were noted during these tests, which are described in test 10. The results are given in table 2 below.

o Mirror Switch Aiming

Mirror switch aiming also was not a problem. This method of operation, which permits the operator to place the radar in his rear window looking backwards while he looks frontwards, did not produce any erroneous readings. Obviously, a non-attentive operator could misread the radar speed portrayed in his mirror, but he would discover his mistake when he reread the displayed speed when writing the traffic citation. These tests were run during field testing.

o External Interference

Each radar unit was evaluated under field operating conditions as described in test 11 to determine the operating range for three different size targets. These data are presented in table 3. While most of these tests were conducted on Highway 52, as noted in the table, several additional tests were conducted on a secondary road, identified as the LOKOT location, which is paralleled by high tension wires. Theoretically, defective high tension wires may affect radar speed measuring devices by causing stray readings or by decreasing the sensitivity of the radar and thereby reducing its range of operation. However, no stray readings were noted in testing near and under high tension wires for any of the models tested.

Table 2. Power-On and kill switch test data.

Radar	Power-on Stat. (sec) (1)	Power-on Mov. (sec) (1)	Kill switch Stat. (sec)	Kill switch Mov. (sec)	Stray readings (4)	Auto lock (2)
A	1.24	25.13	No Kill Switch		7 mph	No
B	2.28	2.42	No Kill Switch		00/100	No
C	2.04	2.10	1.16	1.66	100 mph	No
D	2.13	6.86	No Kill Switch		01 mph	No
E	1.26	2.10	0.23	5.04	Note 3	No
F	2.50	2.57	Note 3	Note 3	100 mph	No
G	0.63	25.38	No Kill Switch		None	No

Note 1. Lapsed time until valid radar speed readings.
Note 2. Did radar unit lock on to a false reading?
Note 3. Last previous valid reading displayed momentarily.
Note 4. No stray readings were recorded when the radar was switched on in the absence of simulated patrol/target speed signal.

Table 3. Radar range test data.

Location	Patrol speed (mph)	Target speed (mph)	Closing time (sec)	Target car	Radar type	Range (miles)	Notes
HWY52	51	53	12.5	veh #1	A	0.36	
	44	49	10.0	"	"	0.26	
	32	68	11.0	"	"	0.3	
HWY52	40	50	39.5	veh #2	H	0.99	1
	52	44	19.7	"	"	0.53	
	40	58	24.7	"	"	0.67	
HWY52	40	39	3.2	veh #3	A	0.07	
	41	50	7	"	"	0.18	
	40	37	4.4	"	"	0.09	
	41	54	9	"	"	0.24	
HWY52	43	51	11	veh #1	B	0.29	
	54	51	13.8	"	"	0.40	
	43	48	14.2	"	"	0.36	
HWY52	43	48	41.2	veh #2	B	1.04	
	53	43	40.5	"	"	1.08	
HWY52	43	51	17.8	veh #3	B	0.46	
	41	45	6.3	"	"	0.15	
	47	50	20.0	"	"	0.54	
	44	46	7.4	"	"	0.18	
	40	37	37.6	"	"	0.8	2
	42	49	9	"	"	0.23	
HWY52	31	43	12.8	veh #1	C	0.26	
	43	48	10.2	"	"	0.26	
	43	55	14	"	"	0.38	
HWY52	47	39	46	veh #2	"	1.1	
	45	36	51	"	"	1.1	
HWY52	36	49	18.5	veh #3	"	0.44	
	32	48	25	"	"	0.56	
HWY52	41	27	30.8	"	"	0.58	
	41	47	26	"	"	0.64	
	41	58	16	"	"	0.44	
	41	50	27	"	"	0.68	

*This radar unit is the same manufacturer model as that used in the tests above with target vehicles 1 and 2.

Table 3. Continued.

Location	Patrol speed (mph)	Target speed (mph)	Closing time (sec)	Target car	Radar type	Range (miles)	Notes
LOKOT	38	37	18	veh #2	C	0.38	3
	37	42	20	"	"	0.44	
LOKOT	37	28	16	veh #3	"	0.29	3
	38	47	8	"	"	0.19	
HWY52	42	53	12	veh #1	D	0.32	
	42	45	4	"	"	0.1	
HWY52	43	60	32.1	veh #2	"	0.92	
	44	48	16	"	"	0.41	
HWY52	41	43	6.4	veh #3	"	0.15	4
	44	50	11.8	"	"	0.31	
	42	44	4.2	"	"	0.1	
	43	55	8.6	"	"	0.23	
	41	35	3.0	"	"	0.06	5
	41	52	4.6	"	"	0.12	
LOKOT	37	51	7.4	veh #1	E	0.18	3
	42	51	17.8	"	"	0.46	
	45	50	20.8	"	"	0.55	
HWY52	42	58	18.4	veh #2	"	0.51	
	42	52	8.5	"	"	0.22	
	40	44	6.5	"	"	0.15	
	42	52	8.5	"	"	0.22	
	43	44	8.1	"	"	0.20	
HWY52	51	48	5.0	veh #3	"	0.14	
	41	39	4.0	"	"	0.09	
	40	38	4.0	"	"	0.09	
	32	37	23.7	"	"	0.45	
	23	43	17.6	"	"	0.32	
HWY52	41	49	4.4	"	"	0.11	
	41	45	4.0	"	"	0.1	
	42	37	3.4	"	"	0.075	
HWY52	42	51	2.0	veh #1	F	0.05	
	32	44	6.0	"	"	0.06	
	38	48	3.5	"	"	0.08	
	41	44	2.0	"	"	0.05	
HWY52	46	65	4.0	veh #2	"	0.12	
	52	50	6.0	"	"	0.17	
	42	35	1.0	"	"	0.02	
	42	47	5.6	"	"	0.14	

Table 3. Continued.

Location	Patrol speed (mph)	Target speed (mph)	Closing time (sec)	Target car	Radar type	Range (miles)	Notes
HWY52	41	50	2.0	veh #3	F	0.05	
	43	50	2.0	"	"	0.05	
	50	50	2.2	"	"	0.06	
HWY52	50	47	6.2	veh #1	G	0.17	
	45	43	5.2	"	"	0.13	
	50	48	12.2	"	"	0.33	
	45	66	12.0	"	"	0.37	
HWY52	40	45	16.0	veh #2	"	0.38	
	50	52	12.0	"	"	0.34	
HWY52	41	49	7.0	veh #3	"	0.17	
	41	33	5.6	"	"	0.12	6
	39	35	15.6	"	"	0.32	7
	40	50	6.0	"	"	0.15	
LOKOT	42	47	11.5	"	"	0.28	3
	44	43	13	"	"	0.3	
	37	51	18.2	"	"	0.44	
LOKOT	sta	46	47.2	"	"	0.6	8
	sta	48	42.0	"	"	0.56	9

Vehicle #1 - Two door Ford Thunderbird
Vehicle #2 - Augmented Winnabego Mobile Home
Vehicle #3 - Two door Ford Pinto

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NOTES:

1. Police car between target and radar vehicle.
2. Picked up and then lost target for several seconds. Picked up another car way behind Pinto.
3. Farm road paralleled part way by high tension power lines on large metal poles.
4. Also measured large truck in stationary mode: 40 seconds at 53 mph, range 0.6 miles.
5. Tracked and displayed truck going 57 mph long before tracking Pinto. Truck was well behind Pinto.
6. Picked up truck at 57 mph, 100 yds behind Pinto.
7. Picked up and then lost target vehicle for several seconds.
8. Patrol vehicle stationary under high tension power lines.
9. Patrol vehicle stationary 100 yards away from high tension power lines.

Four of the radars did not display false readings due to external police radio transmission and only one radar was affected by external CB operation. Radar operations in the vicinity of CB radio transmissions are described in test 14. Radar operations near mobile police radio transmissions are described in test 15.

Radar Unit A: No effect from CB radio mounted in a pickup three feet from the patrol car. Intermittent speed readings from the 100 watt transmitter mounted in a car up to 25 feet from patrol car.

Radar Unit B: No effect from CB radio mounted in a pickup three feet from the patrol car. With radar mounted on dash of the patrol car, the 100 watt transmitter caused readings of 45 and 31 mph up to 20 feet away.

Radar Unit C: No effect from CB radio mounted in a pickup three feet from the patrol car. No effect from the 100 watt transmitter.

Radar Unit D: No effect from CB radio mounted in a pickup three feet from the patrol car. No effect from the 100 watt transmitter.

Radar Unit E: No effect from the CB radio mounted in a pickup three feet from the patrol car. No effect from the 100 watt transmitter.

Radar Unit F: CB radio mounted in a pickup caused readings of 60 to 70 mph at distances up to 175 feet from patrol car. The 100 watt transmitter operated in the compact vehicle caused radar readings at 5 feet from the left rear of the patrol vehicle to 30 feet to the right of the patrol vehicle.

Radar Unit G: No effect from CB radio mounted in a pickup five feet from patrol car. 100 watt transmitter in adjacent car caused no target readings. The radar picked up the correct reading on a passing target car and whistling into the 100 watt transmitter microphone did not effect reading. As the target went out of range, target reading jumped to 44 and 55 for a few seconds.

- Internal Interference

Radars were operated in their usual configuration in a patrol car and the electrical interference due to the patrol car ignition system, alternator, and air conditioner and heater fan motors was investigated. These tests are described in tests 12 and 13. Some of the radar units displayed readings when the air conditioner and heater fans were operated with no radar target present, and one type displayed a reading during the ignition and alternator testing.

Radar Unit A: No interference caused by patrol car or pickup alternator or ignition.

Radar Unit B: No interference caused by patrol car or pickup alternator or ignition.

Radar Unit C: With radar mounted in pickup, erratic patrol speed readings from engine alternator and/or ignition in the moving mode. Extreme interference from heater fan motor (electrical) in the moving mode.

Radar Unit D: No interference caused by patrol car or pickup alternator or ignition.

Radar Unit E: No interference caused by patrol car or pickup alternator or ignition.

Radar Unit F: No interference caused by patrol car or pickup alternator or ignition.

Radar Unit G: No interference caused by patrol car or pickup alternator or ignition.

When a CB radio was installed in the same vehicle as the radar unit, operating from the same battery, several of the radar units were subject to interference during CB transmission.

Radar Unit A: When the CB radio and the radar were mounted in the same truck and connected to the same battery, interference from the CB radio was evident. Interference from the tone whistled into the microphone caused speed readings to be displayed.

Radar Unit B: When radar and CB radio were connected to same battery in truck readings were observed on radar target readout depending on frequency of CB audio.

Radar Unit C: Radar and CB radio connected to same battery in pickup caused readings in stationary mode.

Radar Unit D: Interference from CB radio when radar and CB radio were powered by same battery supply.

Radar Unit E: No effect when radio and radar were both connected to the same battery in the pickup.

Radar Unit F: Not tested because the unit was found extremely sensitive to external CB transmission.

Radar Unit G: Radar and CB radio connected to same battery in pickup caused readings on radar target display. Under these conditions, radar picked up correct reading on passing target car and whistling in CB microphone had no effect on correct reading until target was out of range.

Radar operations in the same vehicle with police radio transmissions are described in test 15. Most of the radars blanked when this took place, but one was not affected and two others were affected. Blanking prevents the operator from using a false reading.

Radar Unit A: 100 watt transmitter blanked out target reading but not patrol reading. Handheld 2 watt radio sometimes blanked out target reading but did not effect correct reading.

Radar Unit B: 100 watt transmitter blanked out patrol and target readings. Handheld 2 watt radio blanked out target occasionally.

Radar Unit C: No effect on readings from either the 100 watt transmitter or the handheld 2 watt radio.

Radar Unit D: 100 watt transmitter had no effect on large targets or strong signals, but it boosted target speeds as much as 20 mph on distant weak signals or small targets. Handheld 2 watt radio had no effect on readings.

Radar Unit E: 100 watt transmitter blanked out both readings. Handheld 2 watt radio had no effect on strong targets, but on several weak targets, the radar displays dimmed and indicated random erroneous readings.

Radar Unit F: 100 watt transmitter blanked out readings on weak signals but had no effect on strong signals. Handheld 2 watt radio blanked out readings on weak signals but had no effect on strong signals.

Radar Unit G: 100 watt transmitter caused increases or decreases of 10 mph in target speed readings intermittently. Handheld 2 watt radio blanked out weak distant targets but had no effect on strong signals.

5. OBSERVATIONS

The manner in which each of the six models of speed measuring units evaluated performs under the eleven situations or environments mentioned in the Florida hearing vary from one model to another. As noted earlier, the limited sample size precludes any attempt to generalize the results to the entire product line of any of the manufacturers, however, for those units that were tested there was no observed degradation of performance arising from 1) cosine angle effect, 2) automatic lock, 3) heat buildup, 4) mirror switch aiming, and 5) high tension power wire interference. With one exception, external CB radio transmission did not interfere with the performance of the radar, and 100 watt police radios transmission did not interfere with the radar units at distances beyond 30 feet from the vehicle in which the radar was operated.

Electrical interference from the ignition and alternator affected two of the radar units, and interference from air conditioner and heater fans was found to affect four of the radars. Operating a CB radio in the same vehicle as the radar interfered with all but one of the radar units that were tested, while only two of the units were affected by transmission from a police radio in the same vehicle. Only one radar unit was affected by transmission from a 2 watt handheld unit in the vehicle with the radar.

All of the radar units but one displayed erroneous readings from patrol car shadowing, and three were affected to some degree by target speed bumping. All of the two piece radars were affected by panning the beam through the display console and all but two of the units were subject to scanning error.

It appears that those circumstances described above that result in target speed measurement error can be avoided by taking precaution in the installation of the radar units and through proper use by a skilled and knowledgeable operator. The scope of the project, however, was limited to testing devices under assumed operating conditions, and did not examine in depth the effect of varying the individual conditions. The observations offered below are based instead upon knowledge and experience gained in the process of designing and conducting the tests. We have not performed studies to investigate the extent to which an operator in taking the conditions into account can avoid the problems cited.

1. Two-piece radars can produce erroneous readings when an antenna is panned through the display console. The radar should not be mounted with the display console in the antenna beam.

2. Air conditioner and heater fans and alternator or ignition noise can interfere with the radar when no bona fide radar target is present. The radar antenna should be mounted so that it is not pointing toward air conditioner or heater fans. If possible, the antenna should be mounted outside of the patrol vehicle.

3. Patrol speed shadowing can occur during moving mode radar operations. Operators should be aware of this and recognize its symptoms, should know its cause and that its effect can best be detected by checking the radar patrol car speed with the patrol car speedometer.

4. Target speed bumping can occur during moving mode radar operations. Operators should know what it is and how it occurs and that its effect can be avoided by maintaining constant speed when making radar speed measurements.

5. The cosine angle effect can occur during stationary radar operation when the target is off axis within the antenna beam. Operators should understand the cosine angle effect and recognize when it is occurring.

6. Transmission from 100 watt FM police radios, both external to and within the patrol vehicle, can cause the radar display to blank or produce erroneous readings. Operators should be aware of this and not transmit on police radios while using the radar.

7. Internal transmission from CB radios can produce erroneous readings. Operators should be aware of this and not transmit on CB radios while using the radar.

8. The use of the automatic lock feature may result in wrong target identification. Operators should be aware of this and not use the automatic lock feature, but instead use the manual lock feature and then only when they have observed sufficient "tracking history" to insure that the correct target vehicle is being tracked.

9. When two or more vehicles are in the radar beam, it can be difficult to select the correct target. Operators should continue radar tracking until the proper target is positively identified; it may be necessary to wait until the vehicles pass by the patrol car and the one being tracked no longer registers a speed on the display console.

APPENDIX A. TEST METHODS

1. Antenna Pattern Half-Power Beam Width Test.

The radar unit was positioned on the base of a vertical test stand in an anechoic chamber with the antenna pointed upwards towards the omnidirectional isotropic probe of a field intensity meter. The probe was rigidly mounted 50 to 100 cm (20 to 40 in) above the face of the radar antenna. The position of the radar was adjusted on the base until the probe was in the center of the antenna beam (on boresight) and the field intensity recorded. The radar unit was then moved to the right and to the left of the probe until half-power was indicated on the meter. The distance between the half-power points was then measured. The distance was again measured while moving the radar on a path perpendicular to the previous direction. The distances between the half-power readings are used to calculate the half-power beam width using the following equation to correct for change in radius distance,

$$A \text{ (degrees)} = 2 f' \text{ ArcTan}(b/r)$$

where f' is a correction factor from the half-power beam width calculation, b is the perpendicular distance from boresight to the half-power point, and r is the distance from the front of the antenna at which the boresight power density was measured. The results of these tests are given in table A-1.

2. Radar Microwave Oscillator Frequency Test.

A small horn antenna was connected to a microwave (μw) frequency counter. The counter was placed in the anechoic chamber where it was convenient to point the radar unit towards the counter pick-up horn. The results of these tests are given in table A-2.

3. Microwave Radiated Power Test

The radar unit was positioned in an anechoic chamber with a field intensity meter having an isotropic probe located on boresight in the far-field (50 to 100 cm). The antenna half-power beam width was then measured as described in test 1 and the approximate total radiated power, P, was calculated from the equation:

$$P(\text{mW}) = 8f'b^2S$$

where f' and b are defined in test 1 above and S is the power density at the distance (radius) at which the half-power point is measured. The results of these tests are given in table A-3.

4. Battery Supply Voltage Variation Test.

The radar unit was connected throught an ammeter to a variable voltage power supply adjusted to 13.6 volts and the supply current recorded. Then the μw radiated power, μw oscillator frequency, and tuning fork tests were performed in the anechoic chamber as described above. The supply voltage was increased 20% to 16.3 volts and the above measurements repeated and recorded. Then the supply voltage was reduced 20% to 10.8 volts and the measurements repeated. Any variation from the nominal values at room temperature were noted for μw power, μw frequency or tuning fork calibration. The results of these tests are given in tables A-2 and A-3.

5. Low Temperature Test.

The radar unit was cooled to -30 degrees Celsius in an environmental chamber and kept at this temperature for thirty minutes. Then the unit was removed from the cooling chamber and the μw power, μw frequency, and supply current were measured in the anechoic chamber, and the radar tuning fork test was performed. Any variation from the nominal values at room temperature were noted for μw power, μw frequency and tuning fork calibration. The results of these tests are given in tables A-2 and A-3.

6. High Temperature Test.

The radar unit was heated to 60 degrees Celsius in an environmental chamber and kept at this temperature for thirty minutes. Then the unit was removed from the oven and the μw power, μw frequency, and supply current were measured in the anechoic chamber, and the radar tuning fork test was performed. Any variation from the norminal values at room temperature were noted for μw power, μw frequency and tuning fork calibration. The results of these tests are given in tables A-2 and A-3.

7. Low Voltage Failure or Alarm Test.

The radar unit was connected to a variable voltage power supply as described in 4. above, and the supply voltage slowly lowered while performing the radar tuning fork test until the radar either ceased to work properly or else emitted an audio or visual warning alarm. The mode of response (failure or alarm) and supply voltage were recorded. The results of these tests are given in table A-4.

8. Tuning Fork Frequency Test.

The X-axis of an X-Y oscilloscope was connected to an audio frequency synthesizer and the Y-axis connected to a microphone. The tuning fork was then struck on a non-metallic surface and held in front of the microphone while the frequency synthesizer was adjusted until a stationary circular lissajous pattern appeared on the oscilloscope. The adjusted synthesizer frequency is the same as the tuning fork frequency. The results of these tests are given in table A-5.

9. Radar Tuning Fork Test.

The radar frequency and frequency-to-speed conversion was verified by striking a tuning fork against a non-metallic surface and then holding it in front of the radar antenna, noting whether the speed indicated by the radar agreed with the tuning fork. Moving mode radar was checked using the two tuning fork method. The first tuning fork was rung as above, then a second higher frequency tuning fork was struck and also held in front of the antenna. The radar must display a patrol vehicle speed based upon the frequency of the lower fork and a target vehicle speed based upon the difference of the frequencies of the two forks.

10. POWER-ON and STANDBY-ON (Kill or Hold Switch) Stray Reading Test.

This test was set up in the laboratory on a simulated range consisting of a test stand with a single-side band modulator driven by a radar maintenance test device capable of simulating both the patrol vehicle speed and the target vehicle speed. The radar was positioned on the test stand adjacent to a start/stop clock and a television camera and video recorder were used to record the radar and the clock readings. The start switch on the clock was connected in conjunction with the radar POWER-ON switch or the radar KILL switch. Moving mode conditions (usually patrol speed 55, target speed 66 mph) were set up on the simulator, the clock set to zero, and the video recorder started. Then the POWER-ON switch or the KILL switch was turned on, starting the clock and activating the radar unit. All radar display readings and

the clock times were recorded on the video tape. Then the video tape was reviewed in slow motion to determine the readings and times which had appeared on the display. The test was repeated in the AUTO-LOCK mode to determine whether or not the unit would accept a stray reading, if present, and lock on to it. The POWER-ON and KILL switch test was then performed during the road test in actual operating conditions.

11. Range Test.

Range tests were conducted in two locations. One was a straight stretch of open two lane highway 1.8 miles long. Each radar unit, in turn, was properly mounted in or on a Matador four door sedan patrol car. Three types of vehicles were used for the target vehicle, an augmented Winnabego recreation vehicle for a large target, a Thunderbird two door sedan for a medium target, and a Pinto two door hatchback for a small target. The patrol car and target car approached each other at a constant rate of speed. As soon as the target vehicle was detected by the radar, a stop watch was activated and then stopped when the two vehicles were directly opposite each other. The constant speeds of both vehicles were read on the radar unit readout and verified with each speedometer via two-way radio. The radar range was calculated from the equation:

$$\text{Distance} = (\text{Target speed} + \text{patrol speed}) \times \frac{\text{closing time}}{3600}$$

Similar tests were run on a 1.3 mile straight farm road paralleled part way by high tension wires on large metal poles immediately adjacent to the roadway.

12. Alternator and Ignition Interference Test.

The car engine was started and turned off several times and the engine was slowly accelerated with the radar on and the antenna pointed out through the windshield or mounted in a dash mounting with no radar target available. The test was accomplished in a four door sedan and in a pickup truck.

13. Air Conditioner/Heater Fan Interference Test.

The radar was operated while mounted on the dash or window, either inside or outside the vehicle, with the heater or air conditioning fans turned off or on at various speeds with no radar target available. When interference was detected, the fan motor was turned off noting whether the interference stopped immediately or gradually decreased in speed as the fan speed decreased. If the interference stopped immediately, the interference was considered to be electrical. If not, it was considered to be generated by the fan blades. The radar antenna was then handheld and aimed at the dash and panned with the fans operating at various speeds. Tests for fan interference were also made with the antenna aimed out the driver's window, the rear window and the passenger side window.

14. Citizens Band Radio Interference Test.

A five watt CB radio and a base-loaded mobile roof mount antenna were mounted in a pickup truck which was then parked five feet away from the patrol car equipped with a handheld or mounted radar gun. Tests were performed by keying and whistling into the CB microphone at various frequencies. If interference was detected, the tests were repeated as the truck approached the patrol vehicle from 150 feet away. The tests were also performed with the CB radio and the radar in the same vehicle powered by the same battery.

15. Police Radio Interference Test.

A 100 watt police communications FM radio and a 5/8 wavelength 2.5 dB gain roof mount antenna were mounted in a two door compact car five feet away from the patrol car which was equipped with a handheld or mounted radar. With the radar on, tests were performed by whistling into the police radio microphone at various frequencies. The tests were repeated as the compact approached the patrol vehicle. The same tests were performed with the police radio and the radar in the same vehicle powered by the same battery. A 2 watt handheld FM radio was also operated in the patrol car with the radar to check for interference. A blanked radar display from radio interference was not considered an erroneous reading.

16. Moving Mode Patrol Speed Shadowing Test.

This was a road test to examine the tendency of a moving mode radar unit to adopt the difference speed between a slower moving truck and the patrol car for calculations of patrol speed. This tendency would result in an erroneous target speed reading. The test consisted of approaching slower moving trucks from behind while continuously comparing the radar patrol speed reading with the patrol car speedometer.

If patrol speed shadowing occurs, the radar patrol speed will read the closing speed with the truck rather than with the ground. The same effect may occur when a large truck overtakes and passes the patrol car.

17. Moving Mode Target Speed Bumping (Batching) Test.

Moving Mode target speed bumping occurs if the radar target vehicle speed varies when the radar car changes speed while operating in the moving mode. This effect may occur if a radar unit does not read and update the patrol speed and the target speed simultaneously. This test was conducted by rapidly accelerating and decelerating the patrol car and observing the target vehicle speed while doing so.

Table A-1. Radar beam width.

	Radar unit						
	A	B	C	D	E	F	G
Half-power beam width (degrees)	13.3	20.4	17.5	18.8	18.6	24.6	14.3

Table A-2. Oscillator frequency measurements.

Test condition/measured parameter	Radar unit A	B	C	D	E	F	G
Ambient temperature & 13.6 volts (MHz)	10522.1	10533.1	10520.6	10539.1	10544.5	10550.9	10517.1
-30°C & 13.6v (ΔMHz)	+11.4	+9.2	+3.8	+7.7	+5.5	+5.1	+9.4
60°C & 13.6v (ΔMHz)	-5.8	-9.4	-4.4	-19.8	-2.9	-4.7	-4.1
Ambient & 10.9v (ΔMHz)	-0.7	-0.6	-2.3	-0.1	-0.1	0	+0.1
Ambient & 16.3v (ΔMHz)	0	-0.1	0	-0.1	+0.1	0	0

Table A-3. Radiation power measurements.

Test condition/measured parameter	Radar unit A	B	C	D	E	F	G
Ambient temperature & 13.6 volts (mW)	85	134	120*	34.25	39.2	26.3	56
-30°C & 13.6v (ΔmW)	0 dB	0	0	0	0	0.2 dB	0
60°C & 13.6v (ΔmW)	---	0	0	0.6 dB	-0.2 dB	0.3 dB	0
Ambient & 10.9v (ΔmW)	-0.35 dB	0	0	0	0	0	-0.87 dB
Ambient & 16.3v (ΔmW)	0	0	0	0	0	0	0
Ambient supply current (ma)	1220	54	1060	250	260	290	1170

*Lensed Antenna: measured with horn and power meter.

Table A-4. Low voltage test data.

	Radar unit						
	A	B	C	D	E	F	G
Battery voltage (v)	11.9	6.0	7.6	10.2	10.3	6.6	11.9
Description	Warning	Blanks*	Blanks*	Fails	Warning	Blanks*	Warning

*Retains correct reading.

Table A-5. Tuning fork accuracy test data.

Radar Unit	Speed Labeled	Speed Calculated*	Frequency (Hz)
A	35	35.51	1114.6
A	65	65.54	2057.0
B	35	34.91	1095.7
B	50	50.01	1569.6
B	80	78.92	2477.0
C	40	40.01	1255.7
C	90	89.98	2824.0
D	--	-----	------
E	35	34.80	1092.3
E	88	87.62	2750.0
F	50	49.87	1565.2
G	35	35.53	1115.0
G	65	65.53	2056.7

*Radar unit displays do not show fractions of a mile per hour.

END