Omnipoint Data

Experimental License Progress Report

to the

Federal Communications Commission

October 28, 1991

Experimental License Issued Dec. 21, 1990

Call sign KF2XEH

File Number 1629-EX-PL-90

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OMNIPOINT DATA
FCC EXPERIMENTAL LICENSE UPDATE

1. OVERVIEW

On December 20, 1990, Omnipoint Data Company, Inc. ("ODC") was granted an experimental license to perform tests of its spread spectrum technologies in the continental U. S. in the ISM bands. Since that time, Omnipoint has conducted extensive testing in a variety of applications and environments, which are summarized herein. Interest in Personal Communications Services ("PCS") has exploded in the past 12 months and Omnipoint has developed subsystems which can provide voice, data, and video to handheld units.

1.1 902-928 MHz Experiments

Miniaturized surface mount spread spectrum direct sequence radio subsystems weighing less than two ounces were developed and tested in a myriad of prototype applications and environments. Spreading bandwidths of 5 - 25 MHz were tested varying the data rates from 9.6 Kbps to 600 Kbps. Processing gains varied between approximately 10 dB and 40 dB.

These subsystems were integrated for testing purposes into a range of potential end user products including digital cordless phones, intercoms, headsets, bar code scanners and handheld computers.

1.2 Propagation

Even at power levels as low as 10 mW and with O dB gain antennas, the systems could operate at ranges in excess of 600 feet line of sight (LOS). At peak nominal outputs of 80 - 100 mW, the systems operated reliably to their digitally-limited maximum range of

1000 feet. Propagation contours followed Rayleigh fading models (at an R^3 attenuation rate) in outdoor environments and Rician fading models (at an R^4 attenuation rate) in typical indoor environments.

1.3 Potential for Interference

The handheld systems tested in field conditions generated less than 15 microWatts per 30 KHz segment on average, thus producing less than 1/40,000 of the interference generated by a handheld cellular phone. The filters employed reduce sidelobe power to a level more than 20 dB below the main lobe, exceeding the requirement for eventual Part 15 certification. (Figure 1)

1.4 Resistance to Multipath Fades

Tests showed that these systems could withstand multipath fades in excess of 30 dB without loss of signal and with minimal degradation to bit error rates (BER). Proprietary techniques were developed and tested which can compensate for the severe multipath experienced in highly reflective indoor environments.

1.5 Number of Users

Data Applications - A base station controller and ten prototype handsets were developed and tested in conjunction with Texas Instruments for a financial exchange trading application. Tests have demonstrated that, even with 1000 users in a single room, the system can handle the peak trading loads which were specified. (See figure 15 for a picture of the spread spectrum modem used inside the handheld computers and figure 16 for a picture of the Omnipoint's spread spectrum base station).

Phones - Using Grade of Service (GOS) and blocked call probabilities comparable to cellular systems, multiuser prototype spread spectrum systems were designed which

FIGURE 1

SUBMITTED UNDER SEPARATE COVER

can handle up to 120 simultaneous full duplex voice channels. Battery operated home cordless phone size handsets were developed and lab tested with base station prototypes. Field, lab, and office tests of these handsets and multiuser base stations were conducted in conjunction with Bell Atlantic and demonstrated extremely high voice quality ("comparable to a wired desk set") over cell sizes which were 10 to 100 times the coverage area of typical CT2 or CT3 systems (per published test results of those systems). Single cell coverage ranged from 300,000 square feet to 3 million square feet depending on the terrain and density of buildings. At average cell sizes of 1 million square feet, less than 30 Omnipoint base stations on average would be needed to cover a square mile

The base stations weigh less than 4 lbs and can easily be mounted on poles or other convenient locations. A PCS or Telepoint-type outdoor network could therefore be constructed initially at extremely low capital costs per square mile.

1.6 2.4 GHz Experiments

Omnipoint has funded development of gallium arsenide integrated receivers which operate from 800 MHz to 2.5 GHz. Initial tests at 2.4 GHz indicate that these will support spread spectrum systems that will work at 2.4 GHz as well 900 MHz, with roughly a tripling in capacity and virtually identical performance.

2.0 Multipath Testing

In order to be able to operate inside an office or other commercial building, the potentially highly destructive effects of multipath must be overcome. Tests have been conducted at numerous indoor and outdoor sites to determine the effects of constructive and destructive multipath on the ODC direct sequence system. The Omnipoint system has been designed from the outset to mitigate these effects as much as possible, and extensive testing has shown that the system performs up to expectations.

Most indoor (office, warehouse, manufacturing, residential) applications tested yield measured delay spreads on the order of a maximum of 500 nsec, as well as frequency selective fades of up to 30 dB. Figure 2 shows a non-degraded received signal, while Figure 3 demonstrates a signal from the same receiver with a frequency selective fade of approximately 35 dB.

Due to the nature of the wide bandwidth employed in our system, as well as other proprietary techniques, the Omnipoint system is able to withstand these multipath effects. In one unique indoor site, a situation was encountered where measured maximum delay spreads experienced were on the order of 1.4 μsec, over a range of less than 600 feet, with frequency selective fades of up to 40 dB. With additional proprietary techniques and enhanced multipath rejection functions, the Omnipoint system was able to perform throughout the entire operating area with no loss of signal and high quality audio.

3.0 Audio System Propagation and Range Testing

The audio test system is shown in Figure 4 and 5. It consists of a cordless telephone type base station which operates on 110V AC supply. A quarter wave, vertically polarized, magnetically mounted antennae was connected to the base through a 10′ length of RG-58 coax cable, and separated at some distance from the base station. This base station was arbitrarily set to service 1 to 4 simultaneous, full duplex, 32kbps ADPCM voice channels. Remote test units consist of battery powered cordless telephone handsets transmitting at 100mW, employing a quarter wave, vertically polarized, SMA mounted antenna.

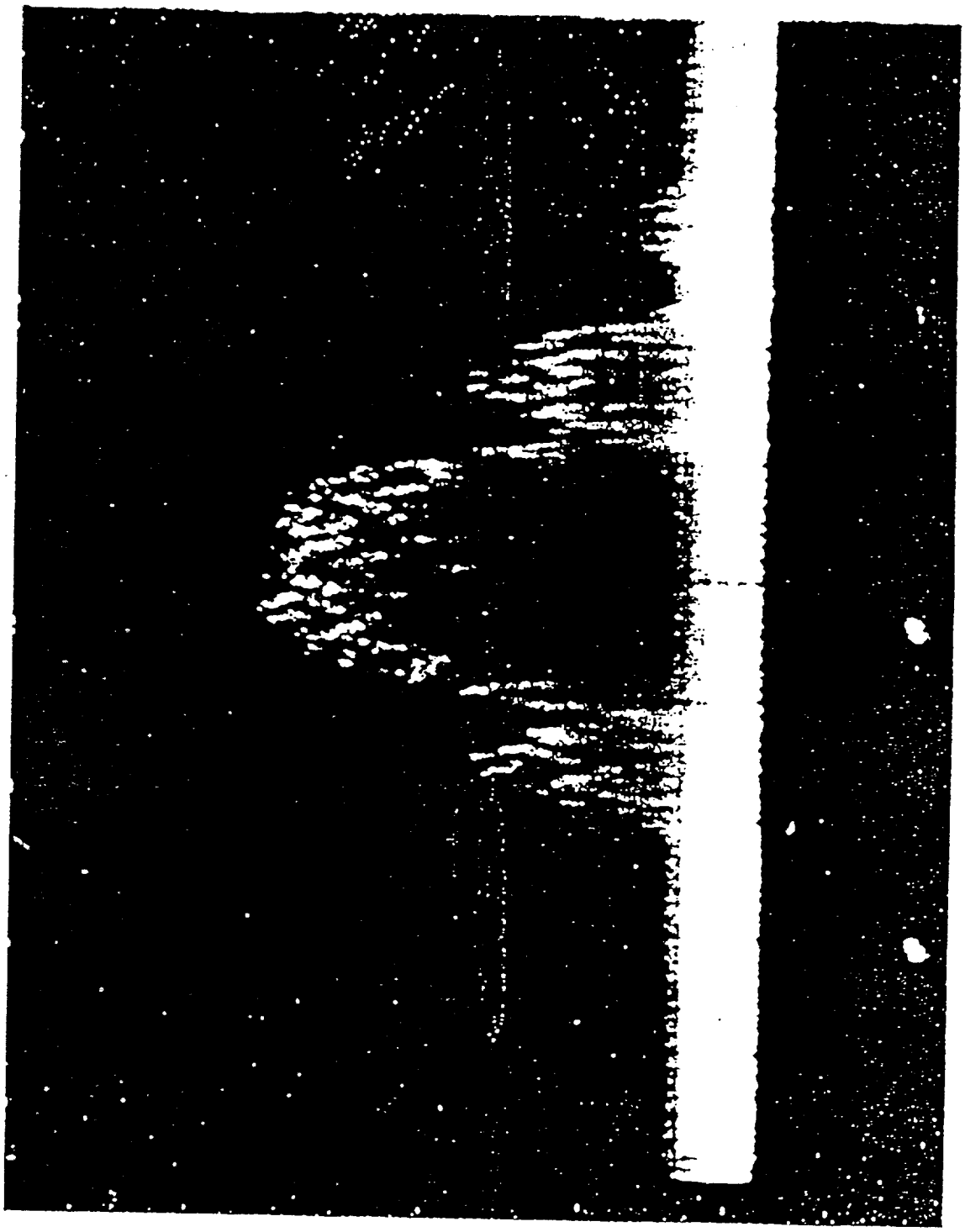


FIGURE 2

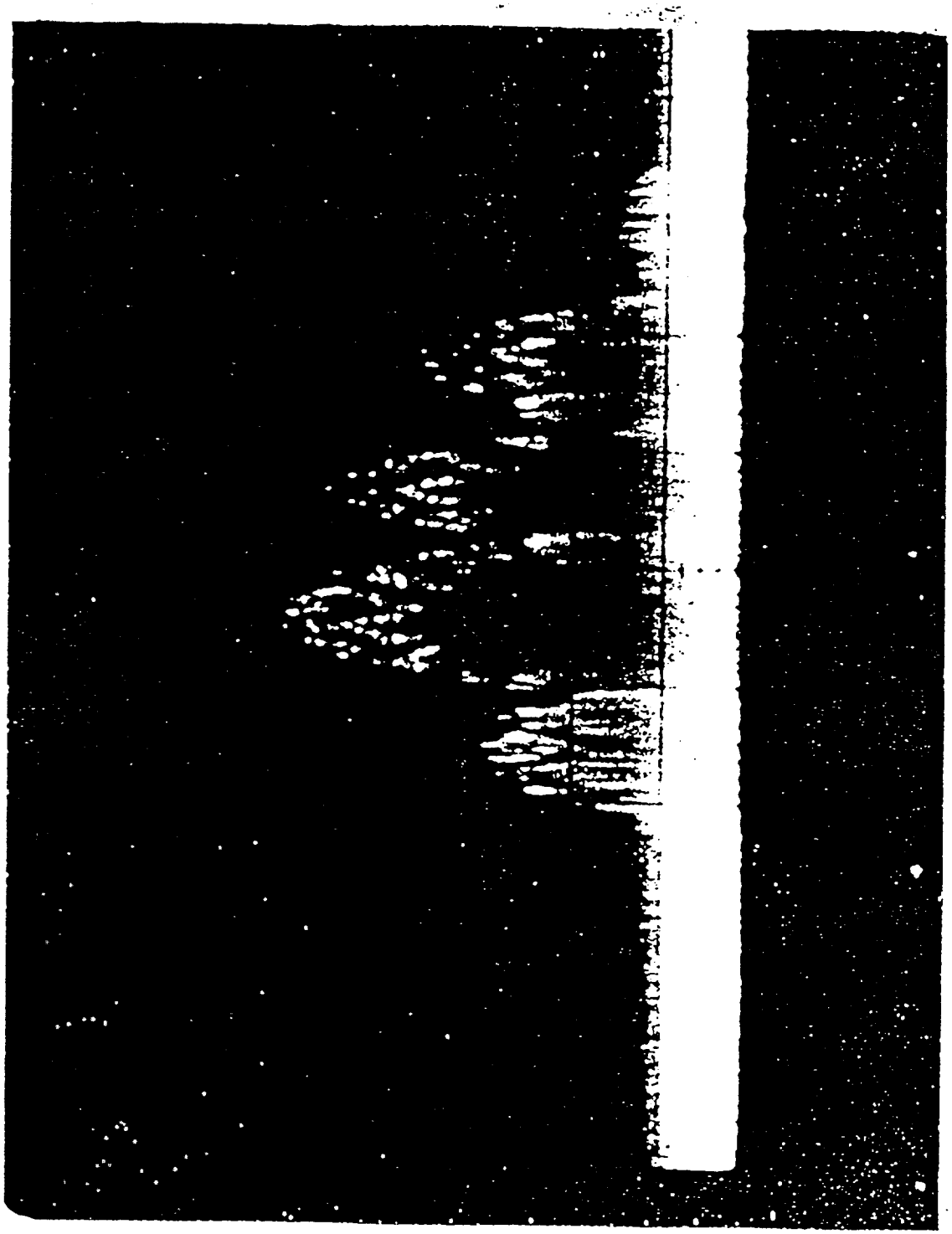


FIGURE 3

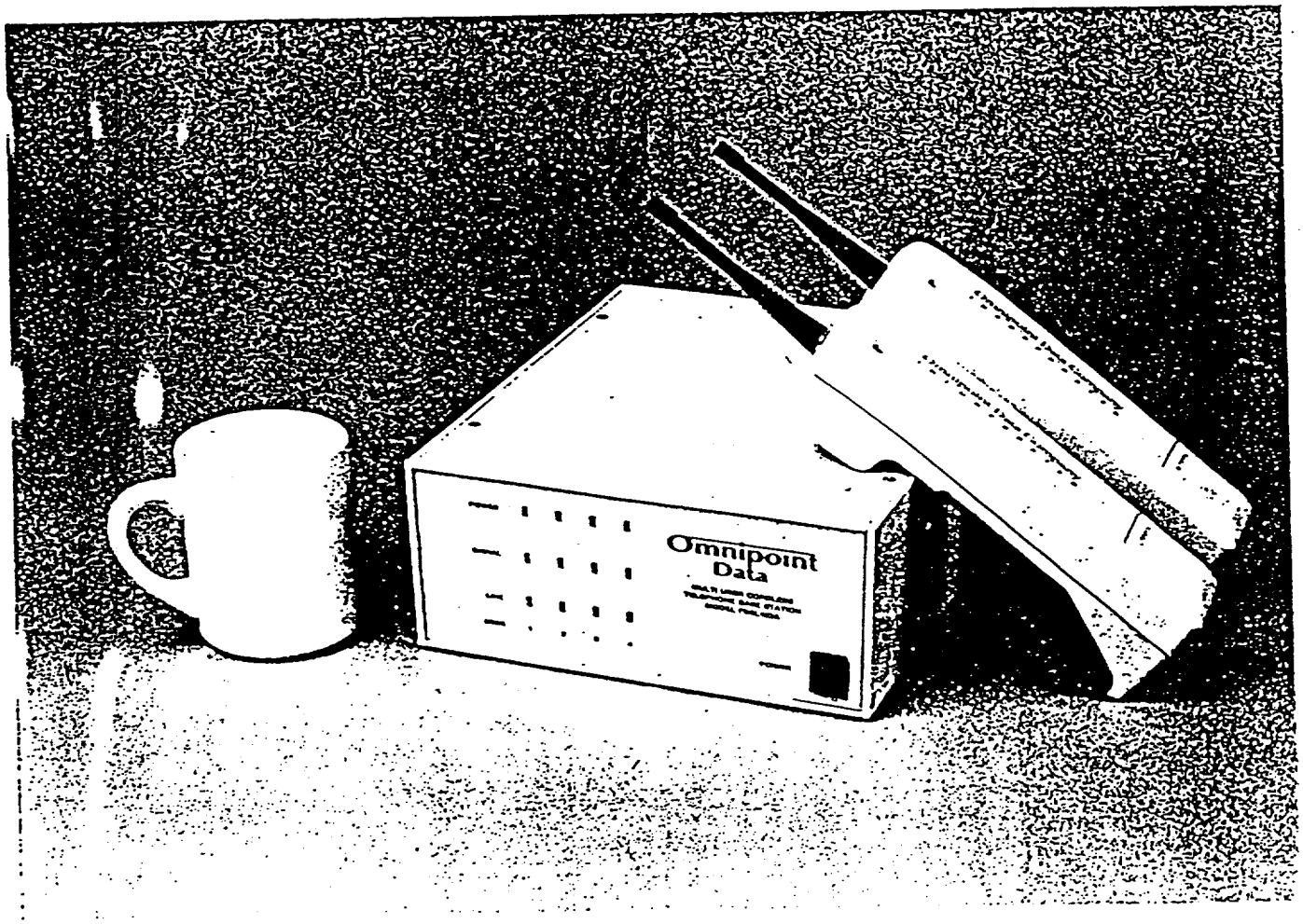
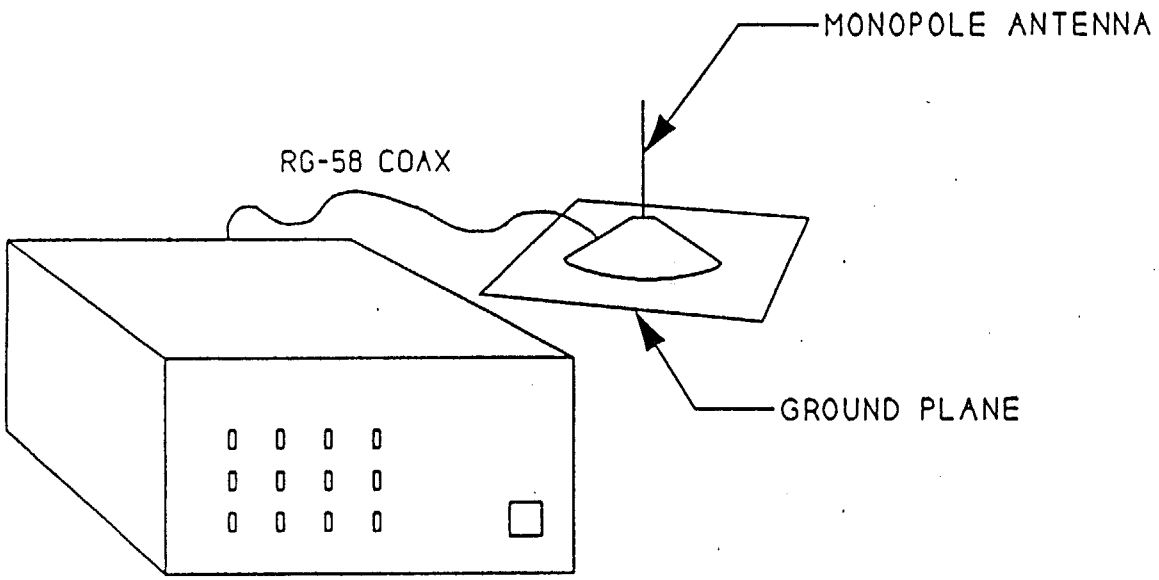


FIGURE 4



4 CHANNEL BASE STATION

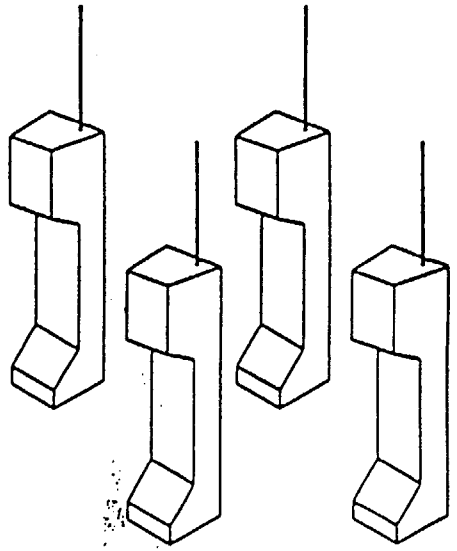


FIGURE 5

Propagation and range tests were performed at various locations, several of which will be detailed here. Subjective audio tests were performed with multiple users both simultaneously and one at a time, and their judgements as to the grade of service in any area were combined to formulate the coverage diagrams.

3.1 Omnipoint Test Site

The site where the most extensive testing was carried out, which is representative of most test sites, is the Omnipoint lab facility, located at 2120 Hollowbrook Drive, Colorado Springs, Colorado. The building is a Class C two story structure of wood joist construction located in a suburban office project. Floor plans are detailed in Figures 6 and 7. With the base station placed in the conference room, full coverage is attained throughout the building, as shown in Figures 8 and 9. Figure 10 shows coverage outside the building, with the base station located in the same position. The neighborhood adjoining the ODC labs consists of hilly terrain with a mix of residential housing units, retail strips, and small office buildings, which in part accounts for the asymmetric coverage plots displayed. The detailed plot plan reveals three zones, which represent various grades of service: Zone 1 represents areas where clear, uninterrupted audio is always available, while Zone 2 includes areas where occasional drops of the signal can be experienced. One of the characteristics of Zone 2, however, is that while it is possible to find highly localized positions where loss of signal can occur, the ODC system is designed and performs such that as soon as the handset is moved out of the null area, the call is recovered. Zone 3 incorporates all areas outside of Zones 1 & 2, and is considered out of range of the base station. It should be noted that in Zone 3 there are many, localized spots where service can be connected, and a normal call can be placed, but one is required to hold the handset in a stationary position once the signal is obtained.

3.2 Bell Atlantic Telepoint Tests

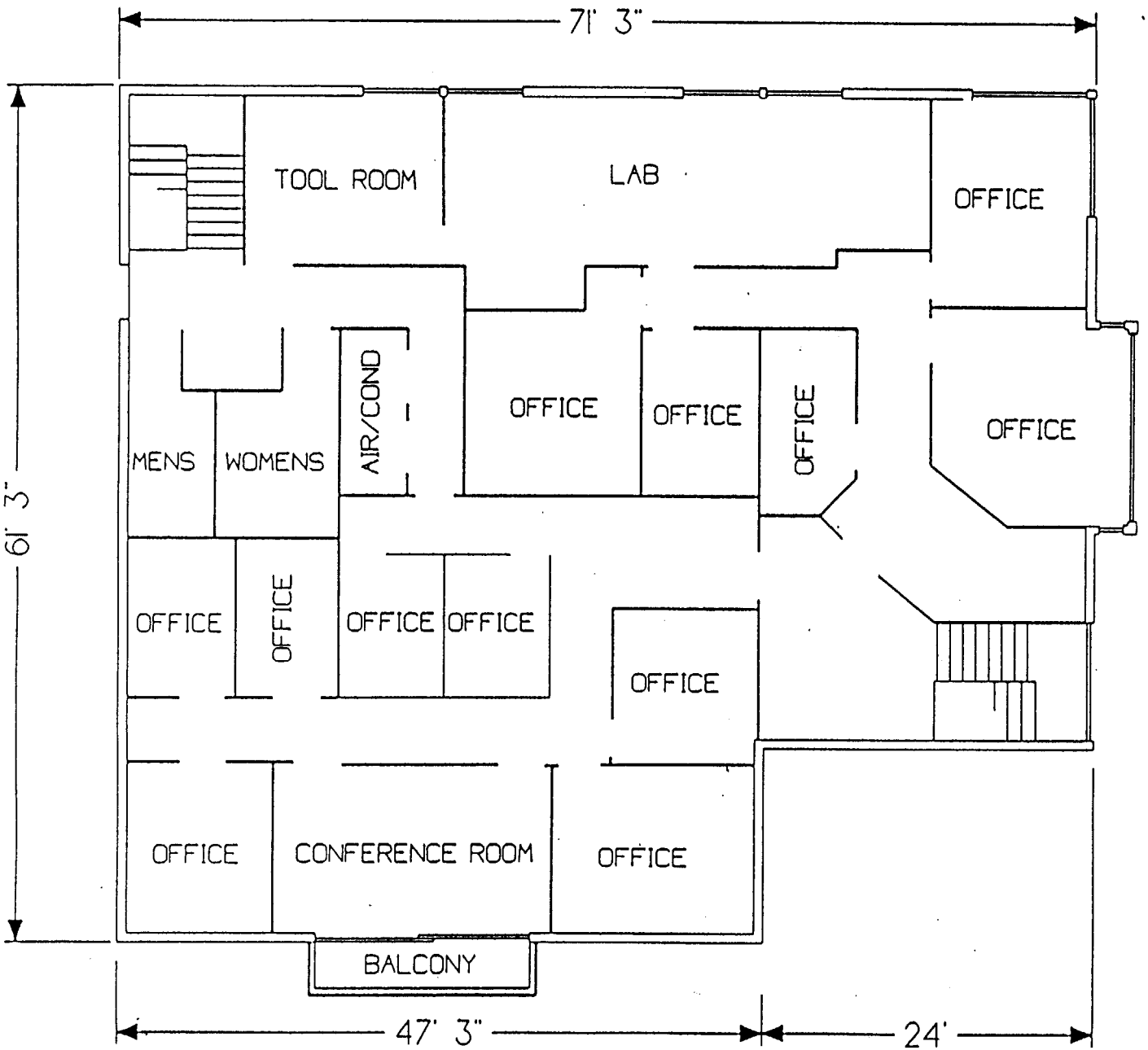
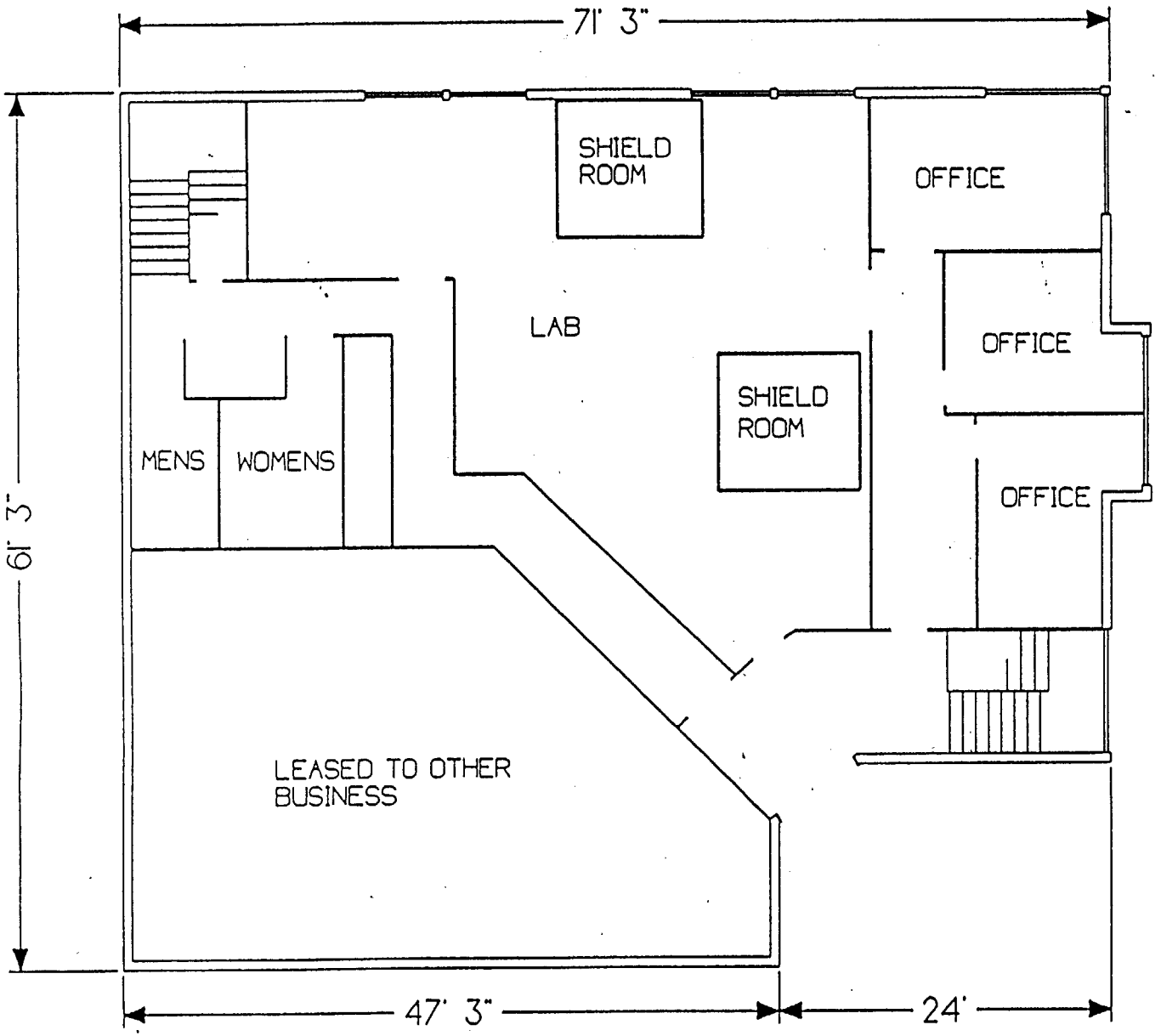


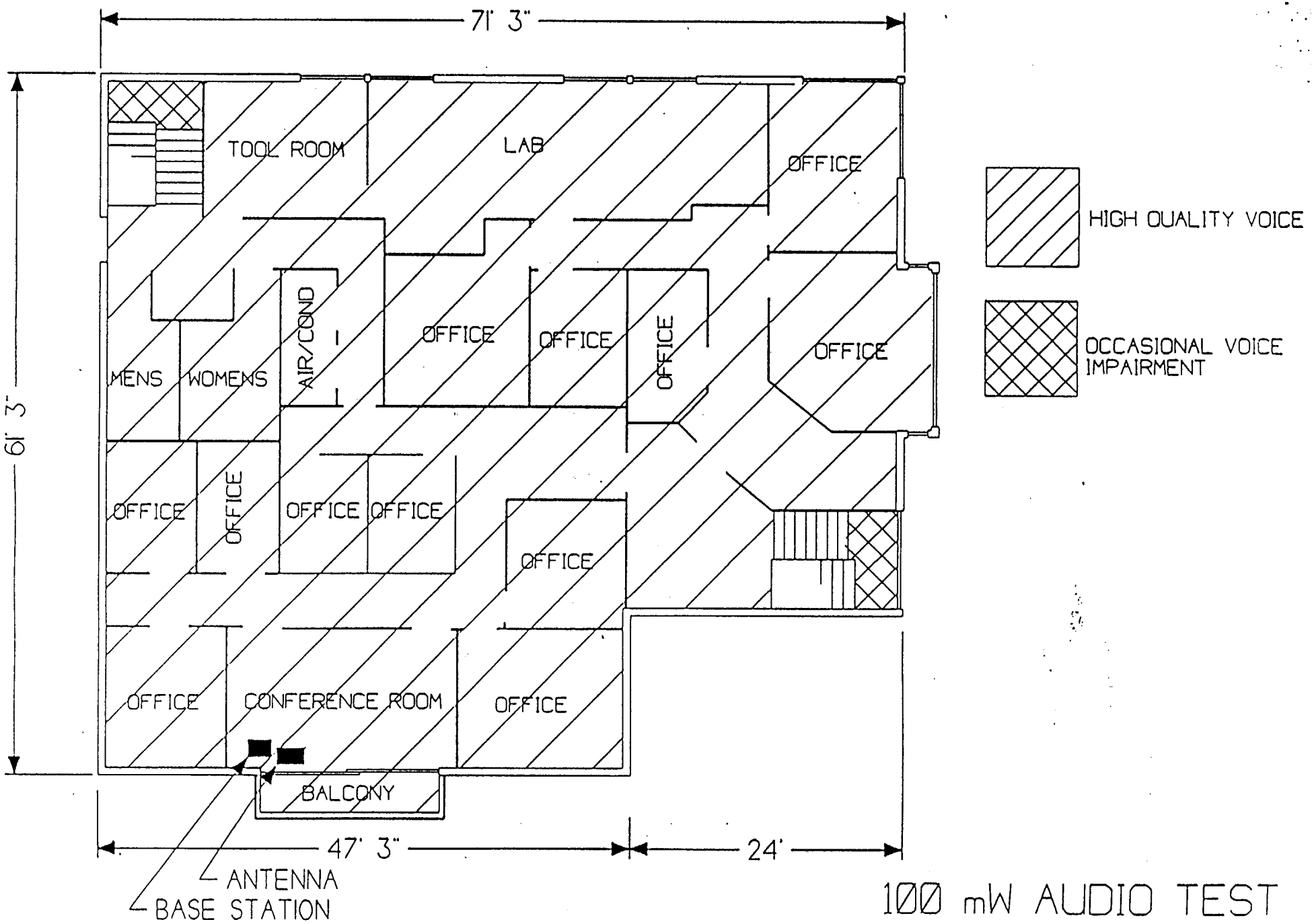
FIGURE 6

SECOND FLOOR
OMNIPOINT BUILDING



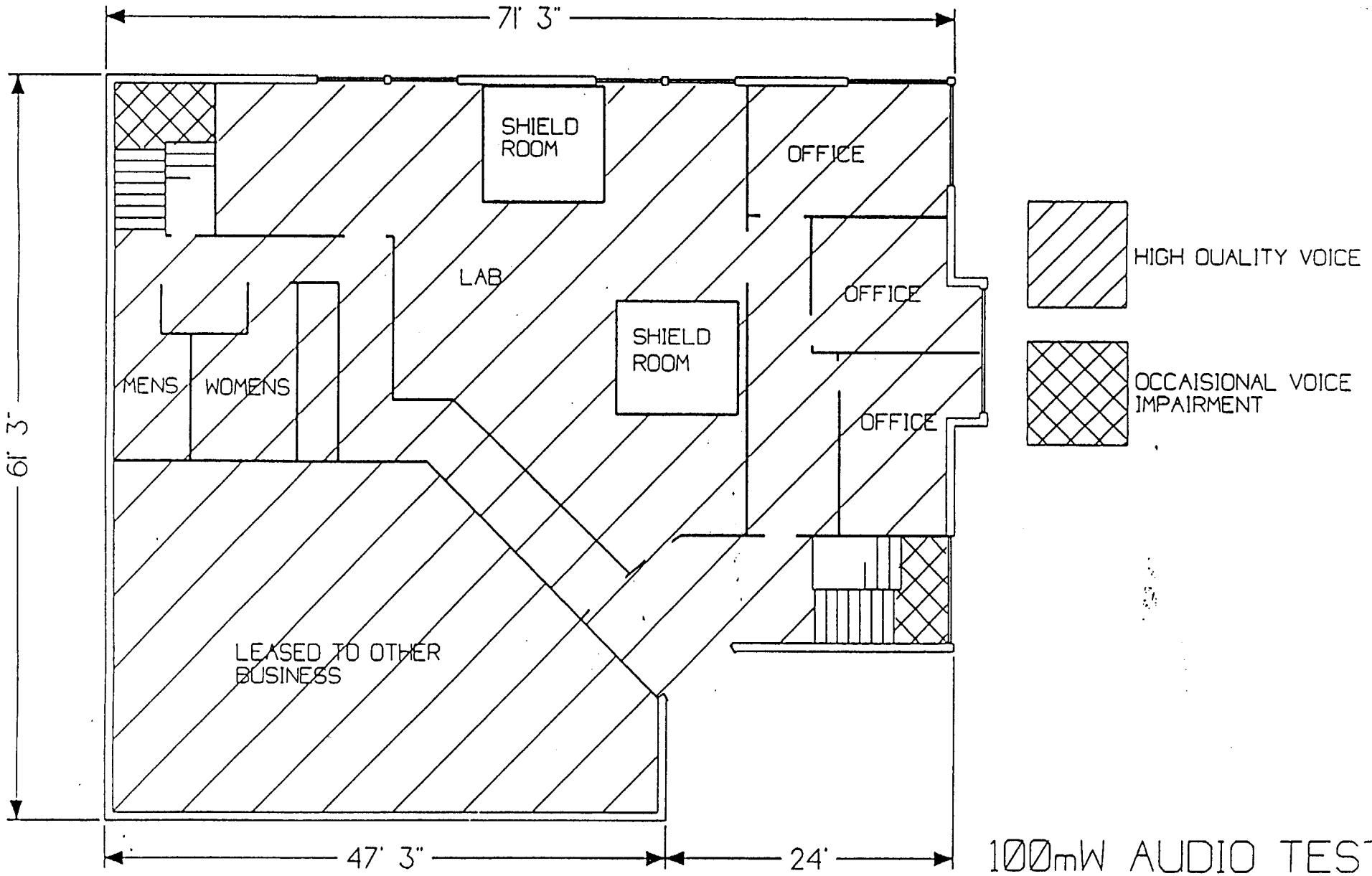
FIRST FLOOR
OMNIPOINT BUILDING

FIGURE 7



100 mW AUDIO TEST
(IN BUILDING)

FIGURE .8



100mW AUDIO TEST
(IN BUILDING)

FIGURE 9

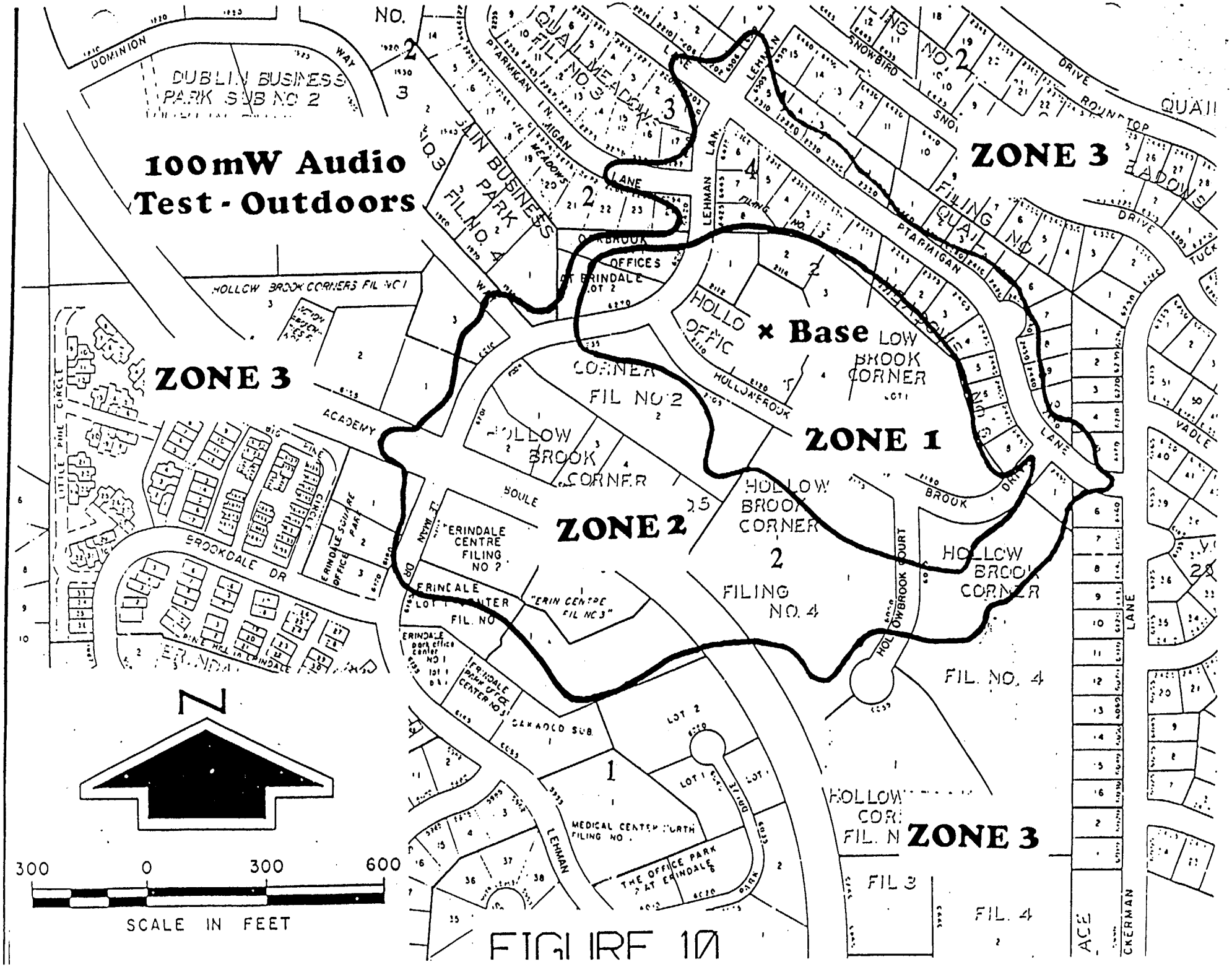

100mW Audio
Test - Outdoors
ZONE 3
ZONE 1
ZONE 2
ZONE 3
Base
DUBLIN BUSINESS PARK SUB NO 2
QUAIL MEADOWS FIL NO 3
QUAIL MEADOWS FILING NO 2
QUAIL MEADOWS FILING NO 1
MAIN BUSINESS PARK FIL NO 4
HOLLOW BROOK CORNERS FIL NO 1
HOLLOW BROOK CORNER FIL NO 2
HOLLOW BROOK CORNER LOT 1
HOLLOW BROOK CORNER 2 FILING NO 4
HOLLOW BROOK CORNER FIL NO 4
ERINDALE CENTRE FILING NO 2
ERINDALE SQUARE PARK
ERINDALE park office center NO 1
ERINDALE park office center NO 3
"ERIN CENTRE FIL NO 3"
OAKWOLD SUB
MEDICAL CENTER NORTH FILING NO 1
THE OFFICE PARK AT ERINDALE
OFFICES AT ERINDALE LOT 2
DOMINION WAY
ACADEMY
BROOKDALE DR
LITTLE PINE CIRCLE
PINE HILL IN ERINDALE
LEHMAN
HOLLOWBROOK COURT
SNOWBIRD DRIVE
PTARMIGAN
ROUNDTOP
TUCK
VADLE
ACE
CHERMAN
FIL 3
FIL 4
N
300 0 300 600
SCALE IN FEET

FIGURE 10

As part of an ongoing partnership, Bell Atlantic has performed tests of Omnipoint technologies in cordless telephony applications in office, residential, and public environments. The public tests included a Telepoint-type application where a base station was mounted at a public payphone site in the Washington D. C. area, and ODC handsets were used to access the PSTN, similar to the Telepoint systems in the United Kingdom. (Figures 11 and 12)

The base station was mounted in a weatherproof enclosure at an elevation of approximately 8 feet from the street, and the power and telephone lines were run from the pedestal to the enclosure. Two omnidirectional, vertically polarized monopole antennas were mounted at a very low elevation of approximately 12 feet, and RF output power was again limited to 100 mW. Remote units utilized were the 10-100 mW ODC telephone handsets detailed above. For this test, only outdoor data was taken. As detailed in Figure 13, seamless coverage, where clear, uninterrupted audio is always available, (defined as Zone 1) was achieved within a 300 foot radius (600 foot diameter) of the base station, with further high quality coverage up to 500 feet down the streets comprising the intersection. Zone 2 includes areas where occasional "clicks" or temporary dropouts of the signal can be experienced, and Zone 3 was determined to include all other locations where quality of service was unacceptable. It should again be noted, however, that a link could be established at many places in Zone 3, especially at the perimeters of Zone 2.

It is critical to note that the base station antennas were mounted at only 12 feet. As noted in several of the CT2 trials optimum coverage required antenna heights of at least 60 feet. It is estimated that Zone 1 high quality coverage could be provided over diameters of 1200 feet with optimum antenna mounting, thereby providing 1 million square feet of coverage per cell.

FIGURE 12

FIGURE 11

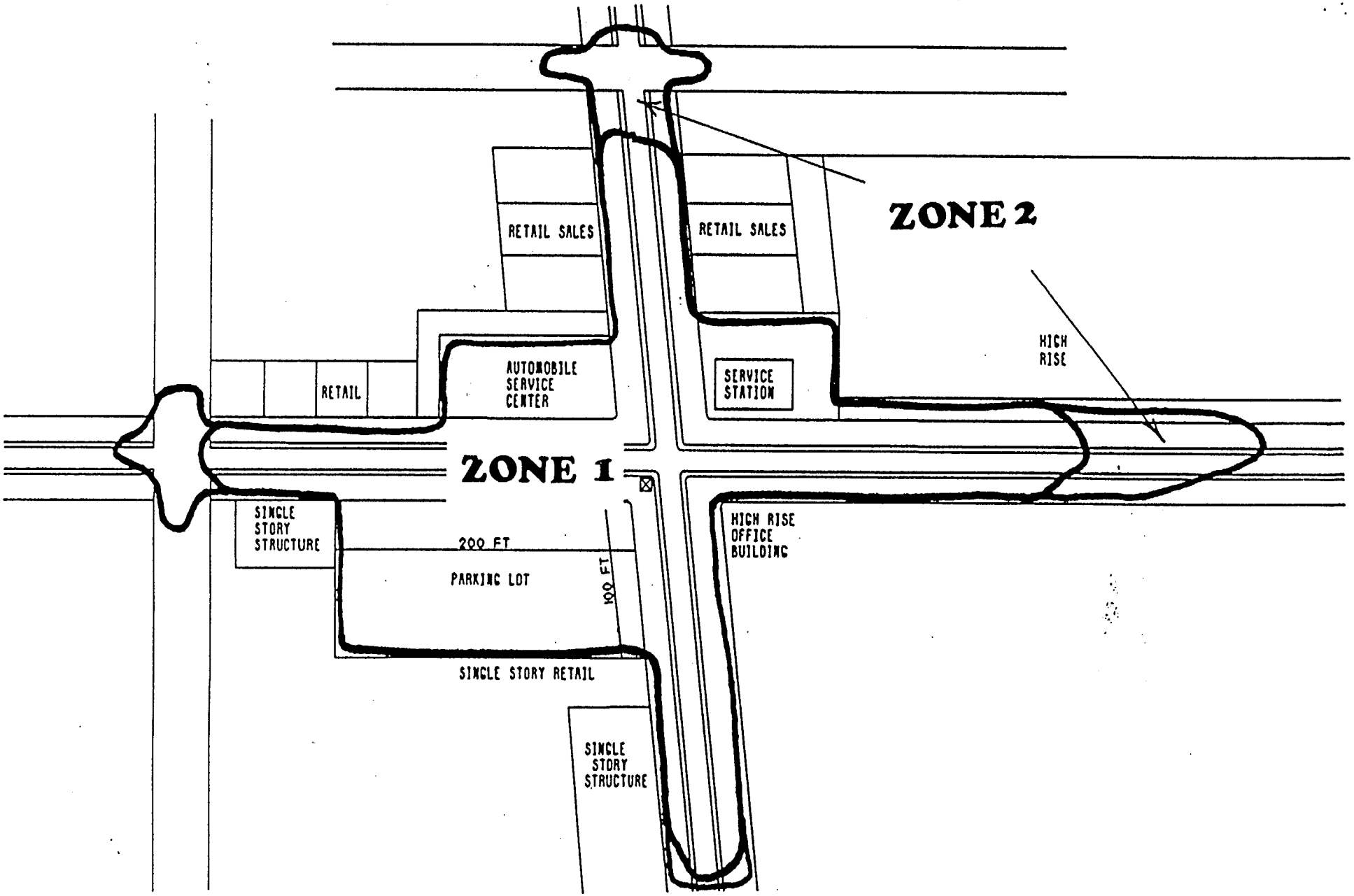

ZONE 2
RETAIL SALES
RETAIL SALES
HIGH RISE
AUTOMOBILE SERVICE CENTER
RETAIL
SERVICE STATION
ZONE 1
SINGLE STORY STRUCTURE
200 FT
PARKING LOT
100 FT
HIGH RISE OFFICE BUILDING
SINGLE STORY RETAIL
SINGLE STORY STRUCTURE

FIGURE 13

3.3 Data System Propagation and Range Testing

Testing of ODC's data developments has been divided into two separate paths:

1) Laptop computer, 1 watt modems (Figure 14)
2) Handheld Commodities exchange trading terminals using 100 mW(Figure 15 and 16)

3.4 Laptop Modems

The laptop modems consisted of the same RF module as the telephone units, with the exceptions that a 1 watt power amplifier was employed, and the user interface was a data stream instead of digitized voice. The spread spectrum RF module was powered by a single 9V radio cell, and a single quarter wave vertically polarized monopole antenna was used on each device. The entire module, measuring roughly 1" x 2" x 6", was plugged into the RS-232 port on the laptop computers.

In the operational mode, the master station addresses the remote units with a message, and the remote units respond. When the remote responded with the correct message, a valid RF link was determined to be present, and when an error in the message or no response was returned, a faulty or no link was deemed present.

Figures 17, 18, and 19 show the coverage achieved with no errors at the ODC lab facilities and surrounding area. As can be seen from the figures, seamless coverage is provided at all points within the building (both floors), and extended coverage outside the building reaches distances of up to two thousand feet. It was determined that in open field, line of site tests, coverage with a 1 watt unit should exceed several miles.

3.5 Commodities Exchange Trading Terminals

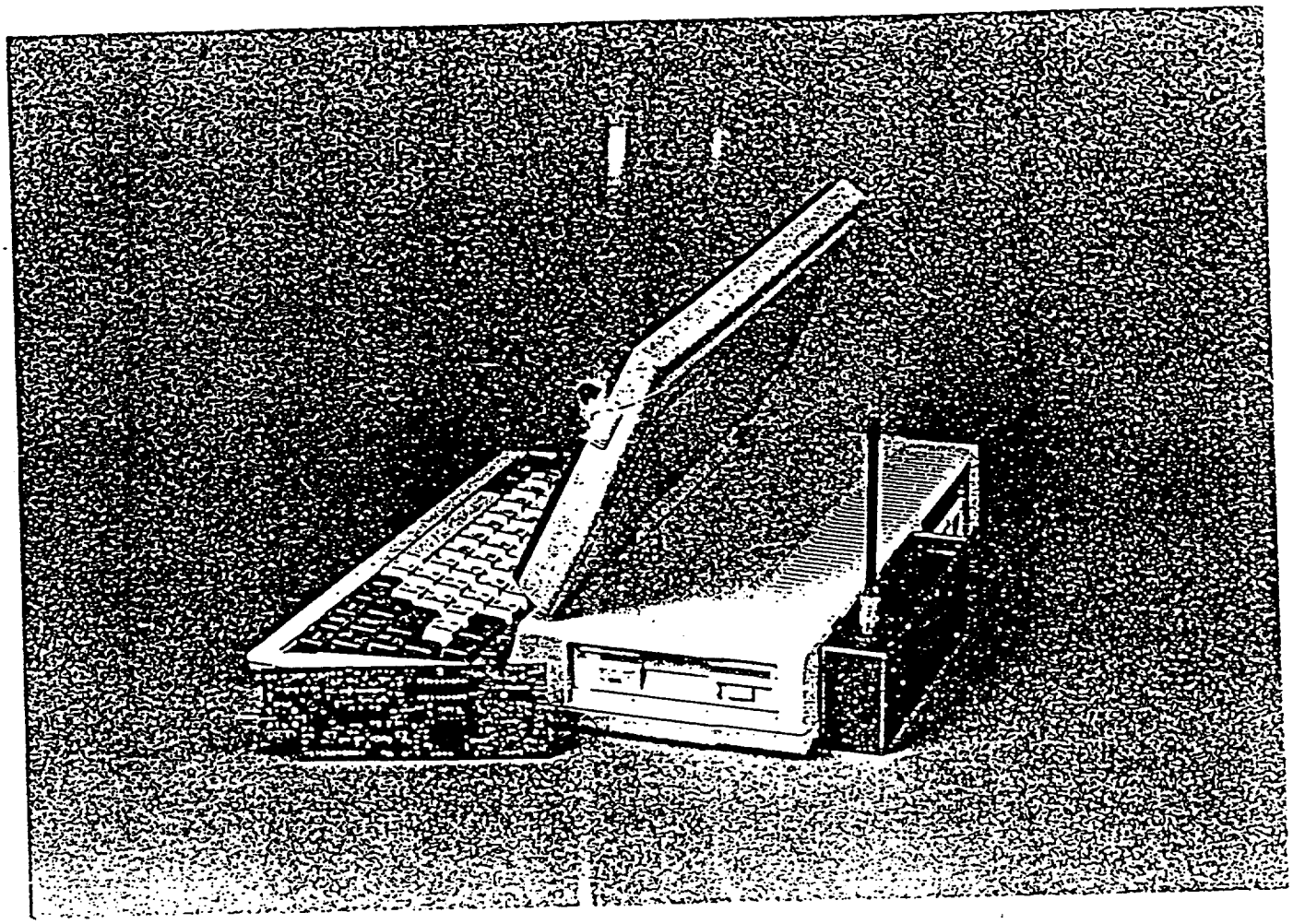


FIGURE 14

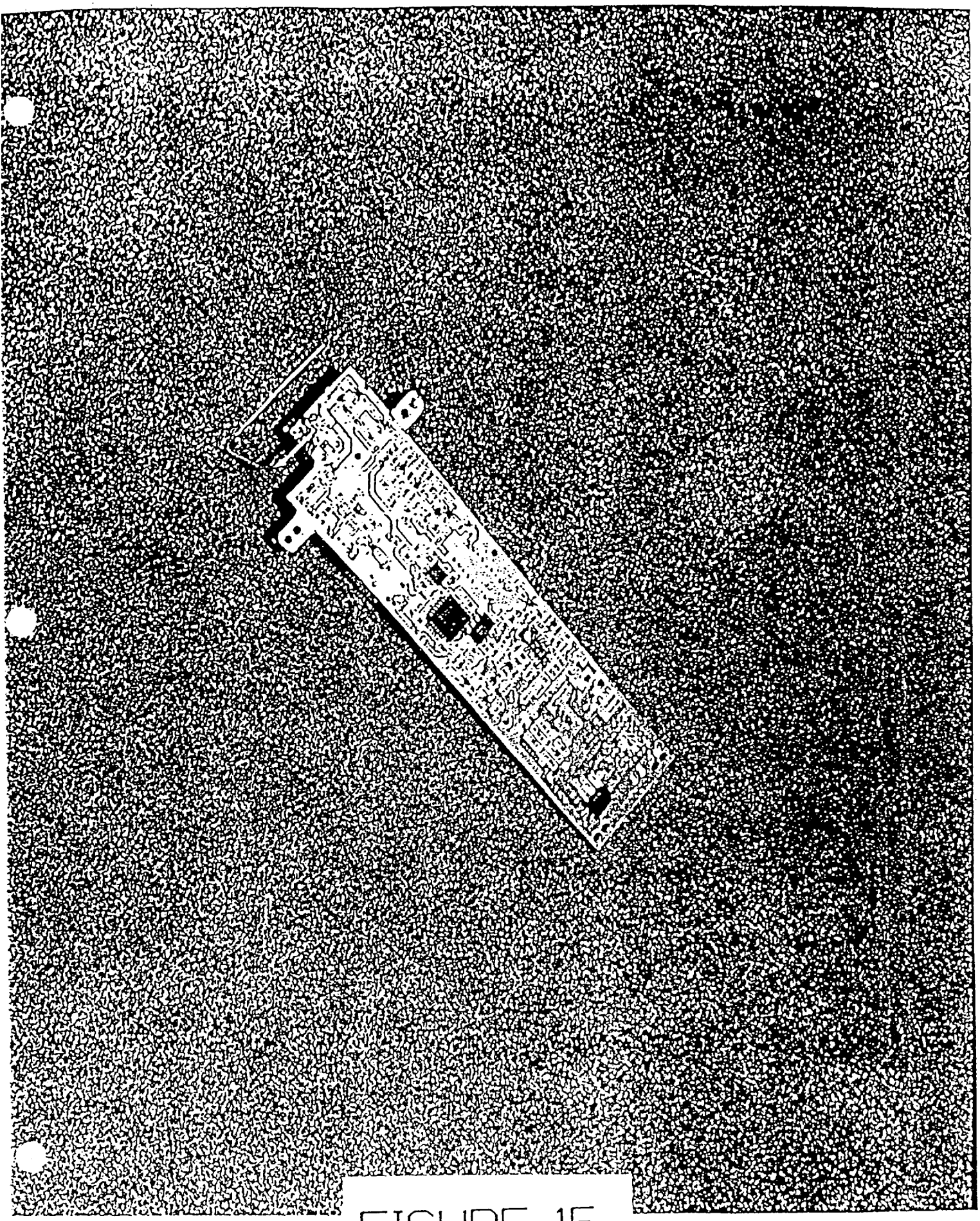


FIGURE 15

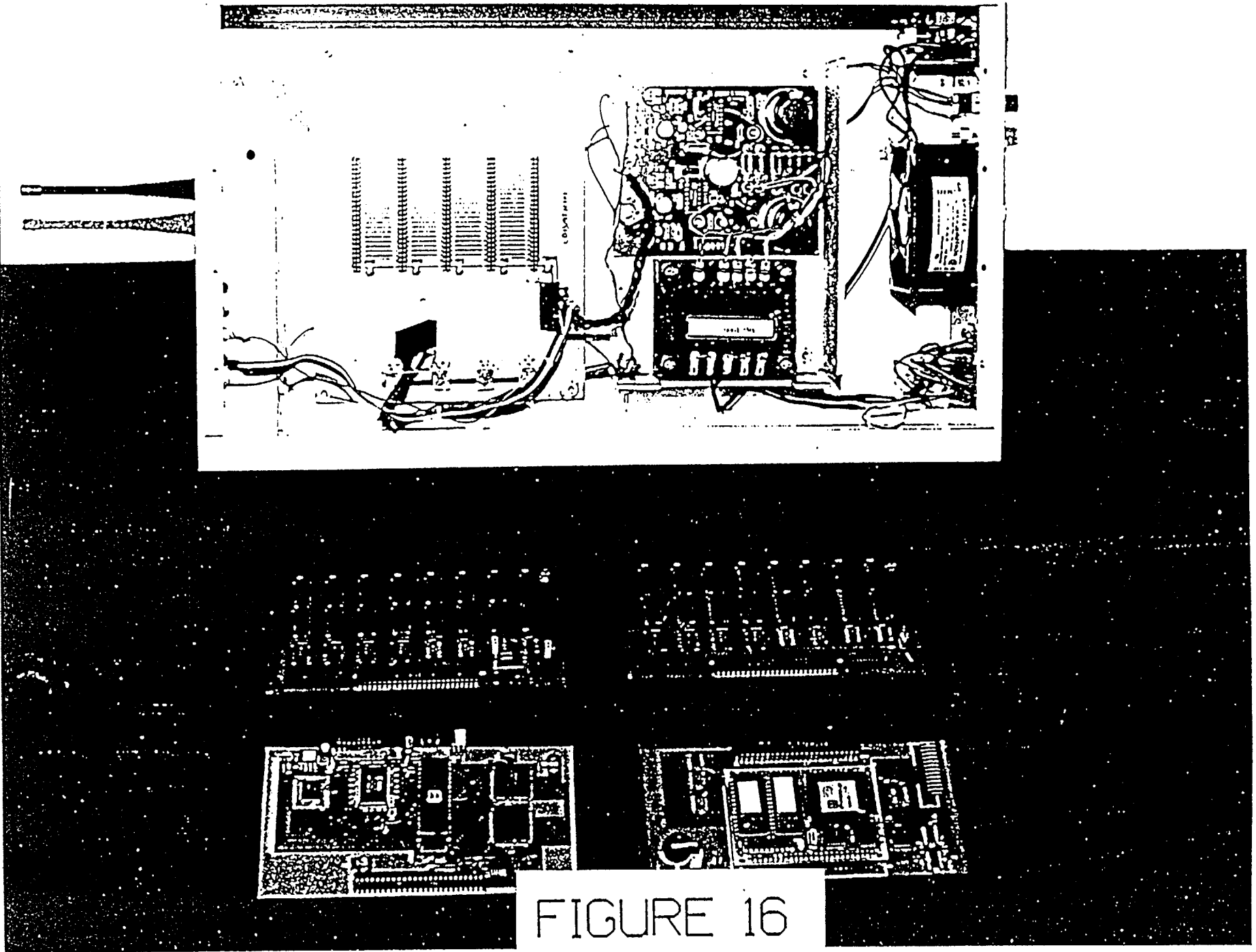


FIGURE 16

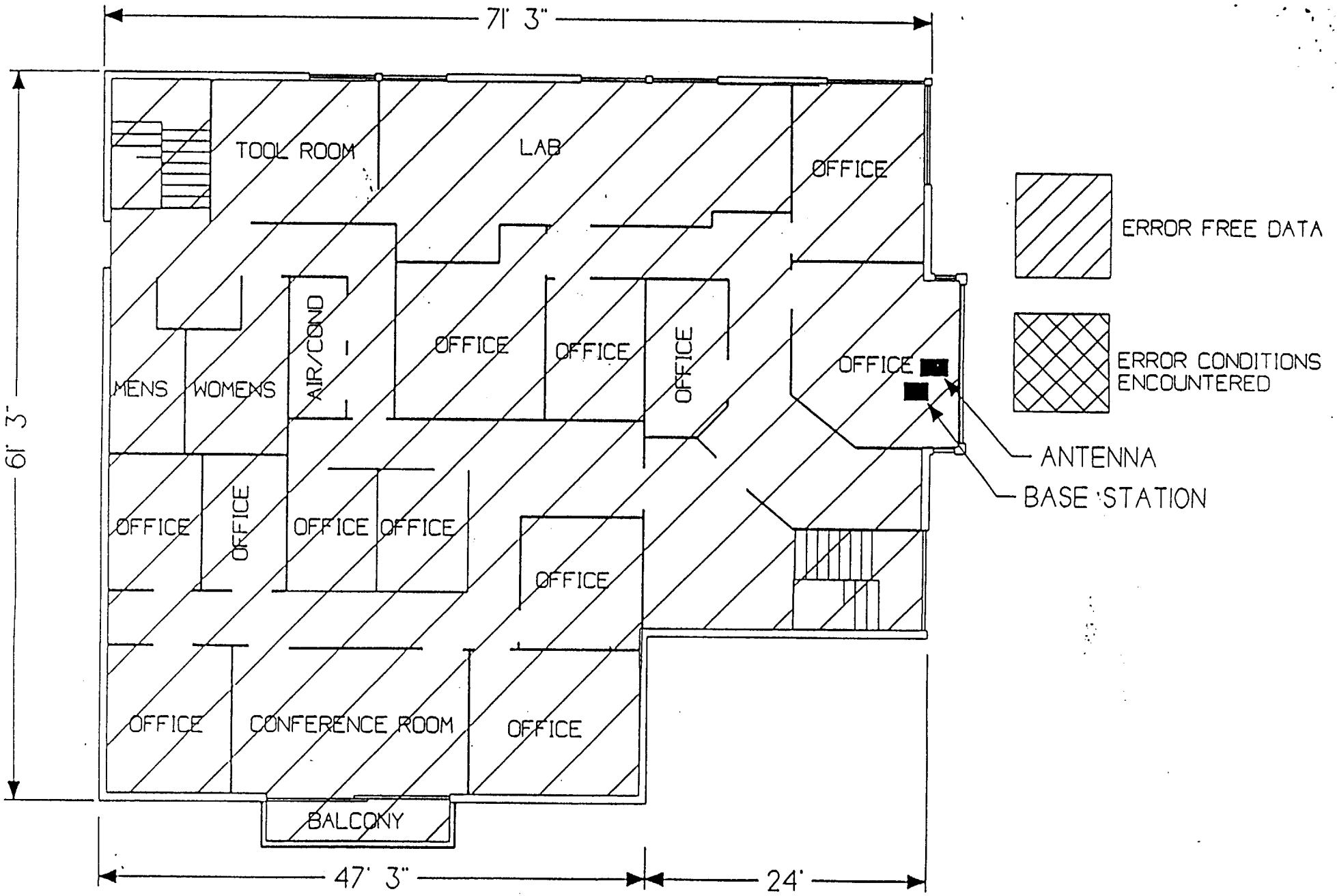
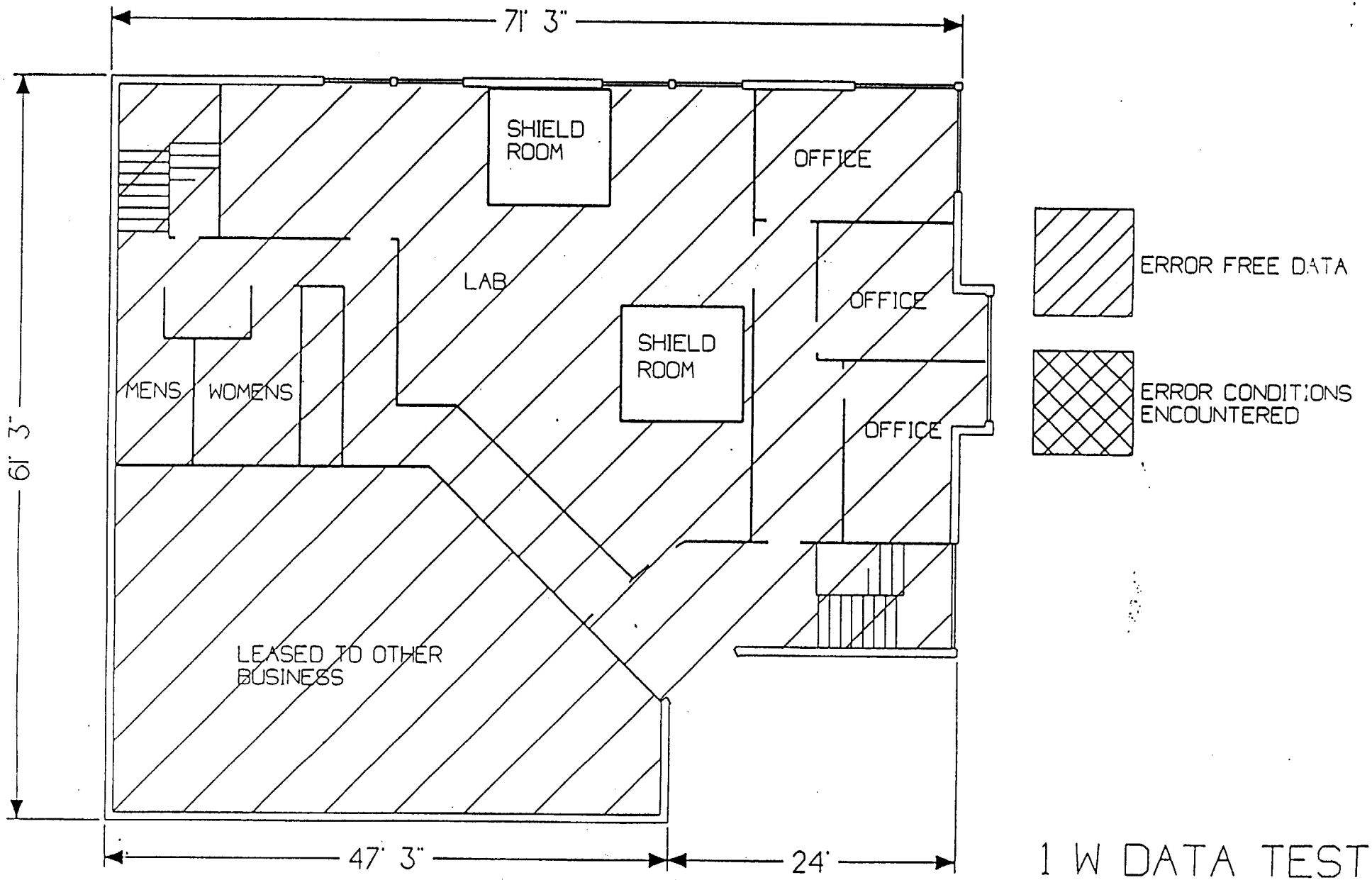


FIGURE 17

1 W DATA TEST
(IN BUILDING)



1 W DATA TEST
(IN BUILDING)

FIGURE 18

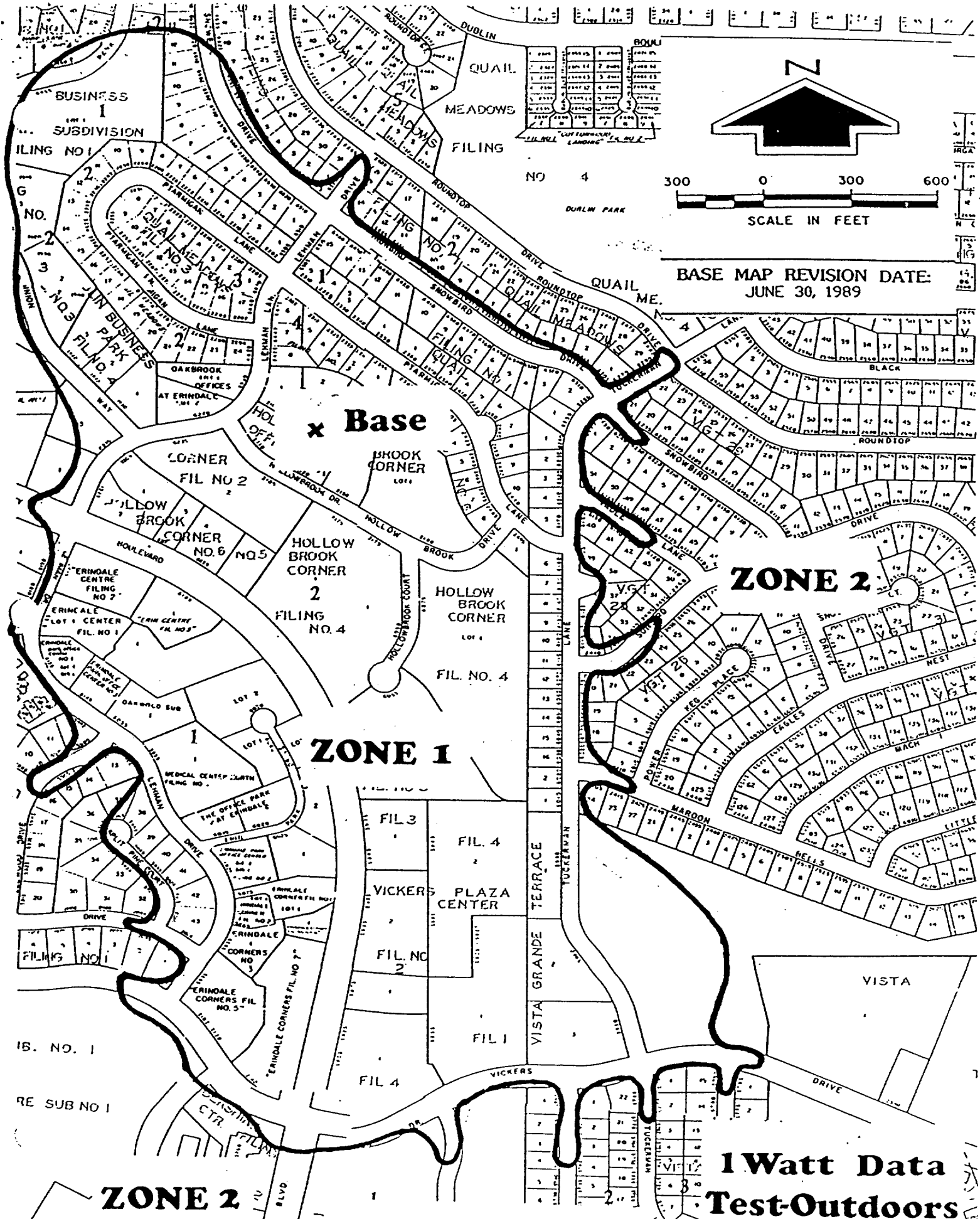

N
300 0 300 600
SCALE IN FEET
BASE MAP REVISION DATE:
JUNE 30, 1989
Base
ZONE 1
ZONE 2
ZONE 2
1 Watt Data
Test-Outdoors
QUAIL MEADOWS FILING NO 4
QUAIL MEADOWS FILING NO 2
QUAIL MEADOWS FILING NO 1
QUAIL MEADOWS FILING NO 3
HOLLOW BROOK CORNER FIL NO 2
HOLLOW BROOK CORNER NO 6
HOLLOW BROOK CORNER NO 5
HOLLOW BROOK CORNER 2 FILING NO 4
HOLLOW BROOK CORNER FIL. NO. 4
VICKERS PLAZA CENTER
FIL 3
FIL. 4
FIL. NO 2
FIL 1
FIL 4
VISTA GRANDE TERRACE
TUCKAWAY LANE
VICKERS DRIVE
VISTA
ERINDALE CENTRE FILING NO 7
ERINDALE CENTER FIL. NO 1
ERINDALE CORNERS NO 3
ERINDALE CORNERS FIL NO 3
ERINDALE CORNERS FIL NO 2
THE OFFICE PARK AT ERINDALE
OAKBROOK OFFICES AT ERINDALE
JOHN BUSINESS PARK FIL NO 4
BUSINESS SUBDIVISION FILING NO 1
DUBLIN
ROUNDTOP
SNOWBIRD
PTARMIGAN
LEHMAN
HOLLOW BROOK DR.
HOLLOW BROOK COURT
BOULEVARD
DRIVE
LANE
WAY
COURT
PLACE
NEST
EAGLES
MACH
MAROON
BLACK
KEG
POWER
BELLS

FIGURE 19

A system enabling traders on the floor of the Chicago Board of Trade and the Chicago Mercantile Exchange to receive orders and register trades was developed in conjunction with Texas Instruments. Preliminary specs required coverage of one trading pit of 30 foot radius with the base station located 30 feet above the trading floor (Figure 20). The system provides 100mW transmit power, and is designed to provide service to 1000 traders in the same room or trading pit.

Preliminary tests at the Texas Instruments facility in Dallas, Texas, and again at the Omnipoint lab facilities in Colorado Springs, show reliable data transfers are able to be put through the system at distances of up to 250 feet from the base.

4.0 Conclusion

Omnipoint intends to use its experimental license to continue to perform extensive testing in all of the allocated spread spectrum ISM bands. It is anticipated that the next six months will see more development and detailed testing in the upper bands with both audio and data devices, as well as continued testing in the 900 MHz band, enabling ODC to maintain its position as leader in the development of high quality spread spectrum communication devices.

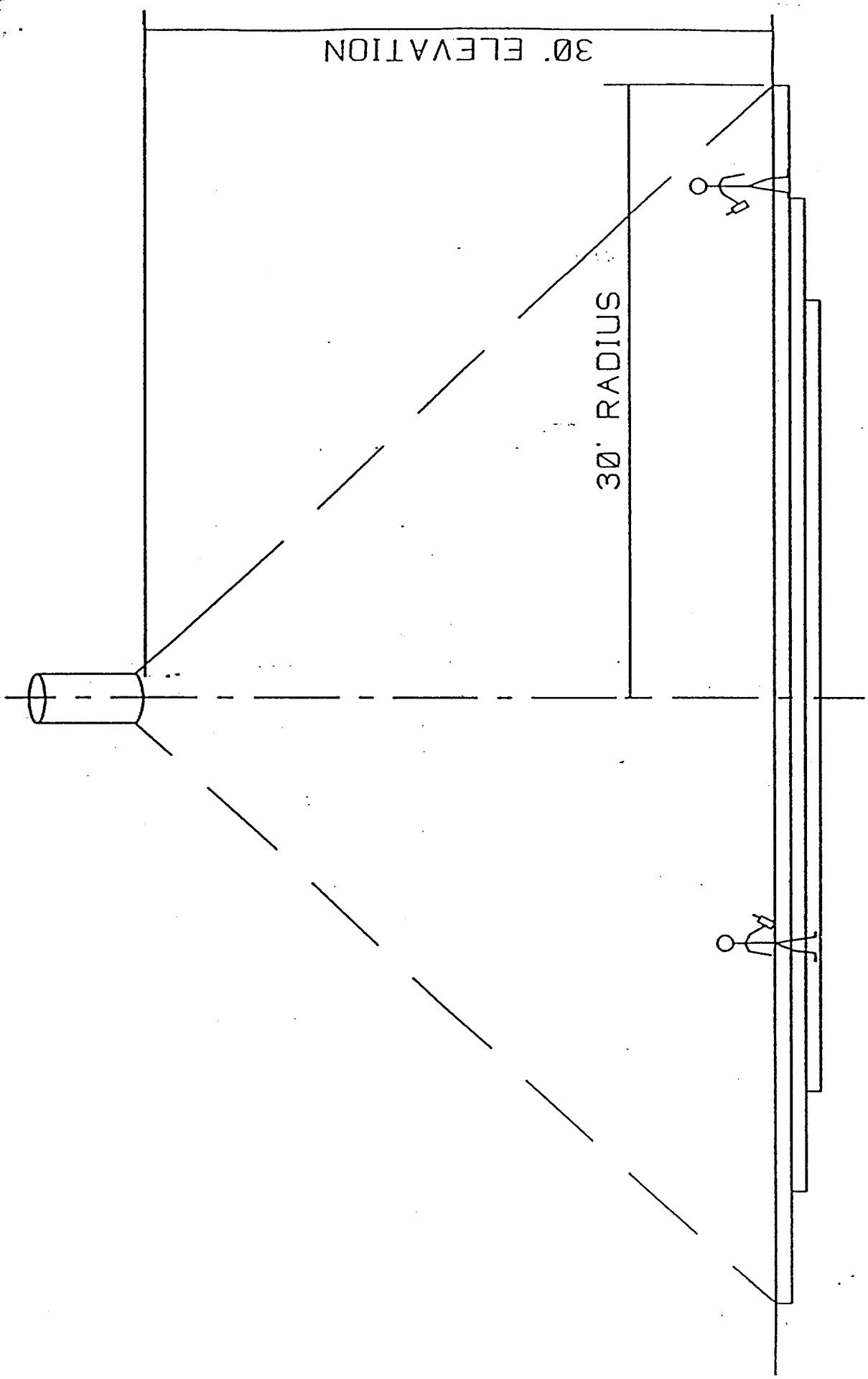


FIGURE 20

PEPPER, HAMILTON & SCHEETZ
ATTORNEYS AT LAW

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WRITER'S DIRECT NUMBER

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October 28, 1991

BY HAND

Office of Engineering and Technology
Federal Communications Commission
2025 M Street, N.W., Room 7002
Washington, D.C. 20554

Attn: Ms. Zina Morrisey

Re: Experimental License KF2XE[illegible] (File No. 1629-EX-PL-90) -- Semiannual Report

Dear Ms. Morrisey:

I am writing on behalf of Omnipoint Data Company to forward the company's first semiannual report concerning the above-referenced experimental license. Please note that page 3 of the report has been submitted under separate cover with a request that it be withheld from public inspection.

Please call if we can answer any questions or provide any additional information.

Sincerely,

David A. Wormser

Enclosure

cc: Douglas G. Smith
Jeffrey Vanderpool