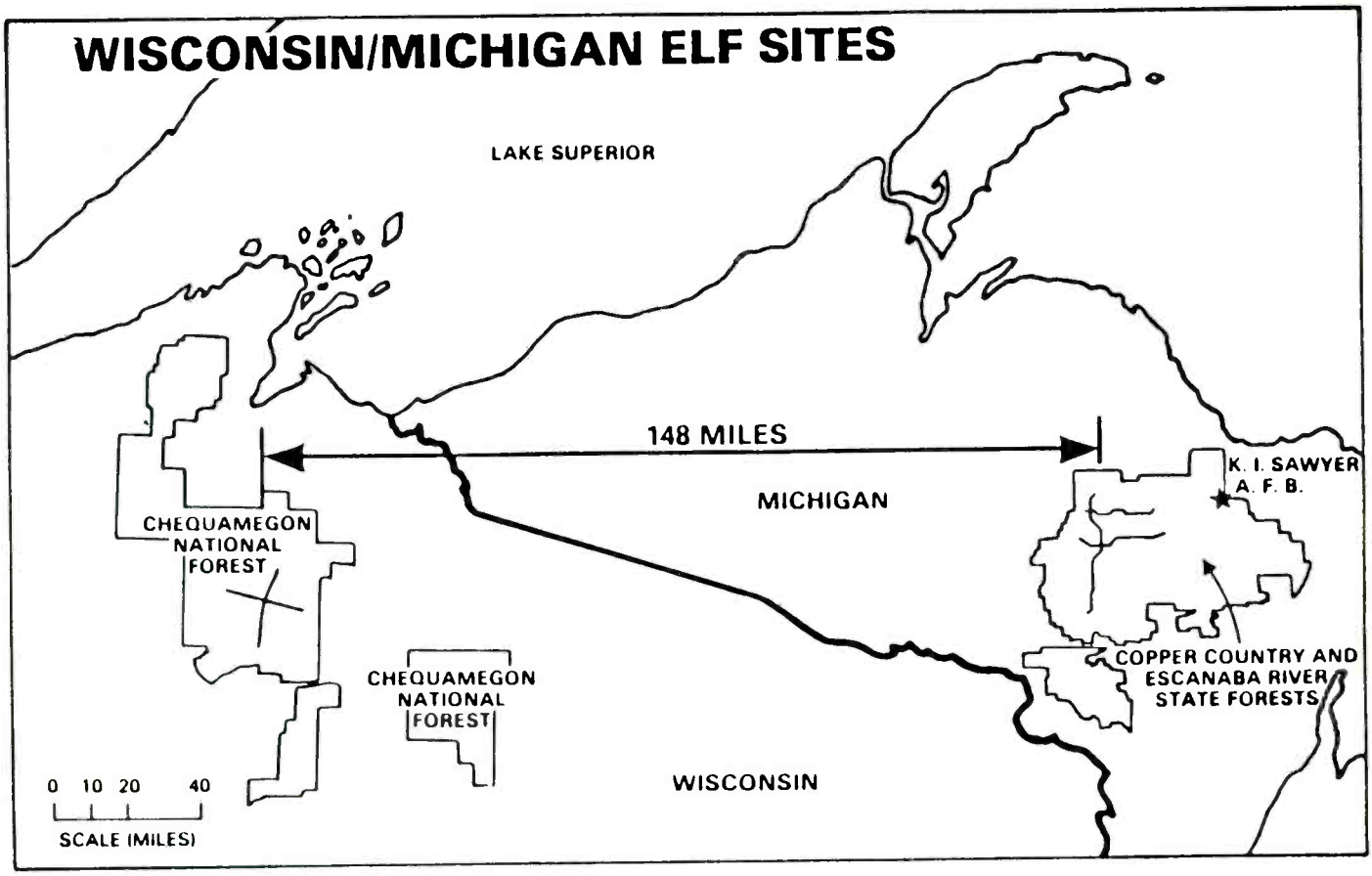


The ELF Is Here!

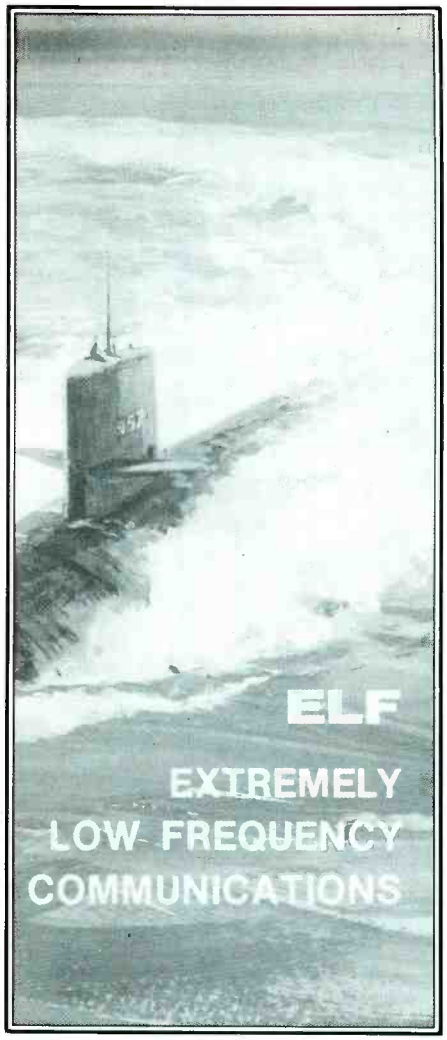
We Visit The New E.L.F. Transmitter Site

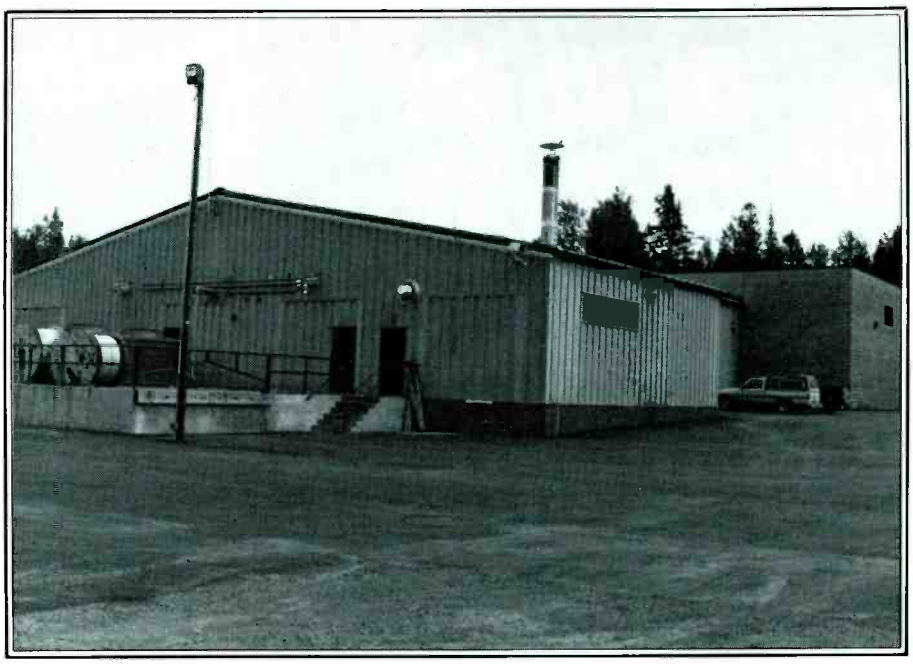
BY TERRY O'LAUGHLIN, WB9GVB

The Navy's Project ELF (Extremely Low Frequency) is certainly the strangest radio system in the world. It has the lowest frequency, 76 Hz, and the highest input power, 2.3 million watts. It is designed to communicate with submarines, but is located 1500 miles from the nearest ocean. It has the least efficient antenna, only 2 to 3 watts of RF is actually radiated. It has the slowest data rate, 15 minutes to send a three letter code group. There are reasons for all these odd characteristics, but first, let's look at the facilities.

Project ELF has two transmitter sites, the Wisconsin Transmitter Facility (WTF) near Clam Lake, WI in the Chequamegon National Forest and the Michigan Transmitter Facility (MTF) near K. I. Sawyer Air Force Base in Michigan's Upper Peninsula. The WTF has been in existence since 1969. It was originally built as a test site for Project Sanguine (which was never completed). After years of inactivity, it was extensively rebuilt and came on line in the summer of 1985. The MTF is under construction. It is expected to come on line in the fall of 1988. A third installation, the Message Input Seg-

WTF main gate, Lt. Cress (left), Master Chief Radioman Rick Badger (right).





WTF main building, contains transmitters, tuning and machine networks, offices, shops and main control room.

ment (MIS) located on K. I. Sawyer AFB, was completed in October, 1985. It is not a radio facility, but, it is an important link in Project ELF's operation. *POP'COMM* was allowed to visit the Clam Lake WTF within weeks after it became a fleet asset.

On the day I arrived, Project ELF was running full tilt, pumping almost 2 million watts into its antennas. The emergency power system was being tested. Three Cummins diesel 1 megawatt generators created a deafening roar as I passed through the generator shed on my way to the transmitter building. A two week supply of fuel is kept on site in underground tanks.

Inside the transmitter building, I could clearly hear the slow FSK alternating the carrier between 72 and 80 Hz. The noise was subtle but eerily powerful. A glance at the antenna monitor panels confirmed my gut feeling, 6400V at 300A. That's 1.92 million watts!

The WTF is designed for independent operation. After the MTF comes on line, the two facilities will operate synchronously with the MTF as a slave. Though the two facilities are 148 miles apart, Project ELF's 2500 mile wavelength makes them look like two elements of the same antenna.

The WTF has four 650 kW transmitters and four 7 mile antennas strung in a big X. The antennnas resemble oversized Beverage antennas with two parallel insulated 1 inch thick stranded aluminum lines 25 to 35 feet above ground. To an untrained eye, they look like power lines. Each antenna terminates in an extensive ground system at the far end.

The MTF will have four 500 kW transmitters and three antennas totalling 56 miles in length strung out in a giant F.

Messages to be broadcast on Project ELF originate at the Commander of Submarine Forces Atlantic (ComSubLant) in Norfolk, VA or the Pacific equivalent, ComSubPac in Hawaii. Messages from ComSubLant arrive at the WTF and MIS on 2400 baud encrypted phone lines. Messages from ComSubLant are relayed through ComSubLant in 100 wpm teletype via phone line, satellite, or HF radio.

Inside the WTF, data from the encrypted phone line is routed through a decrypto unit, into a Sperry-Rand AN/UYK-20 computer set up as the Message Processing Unit (MPU). From the MPU, the data is routed through an encrypto unit to another AN/UYK-20, this one set up as the Transmitter Processing Unit (TPU). When I visited, the Navy had black tarps tied over the highly classified encryption, and decryption, units. Otherwise, I was allowed to examine and photograph everything. The output of the TPU drives the modulator which generates the world's slowest FSK.

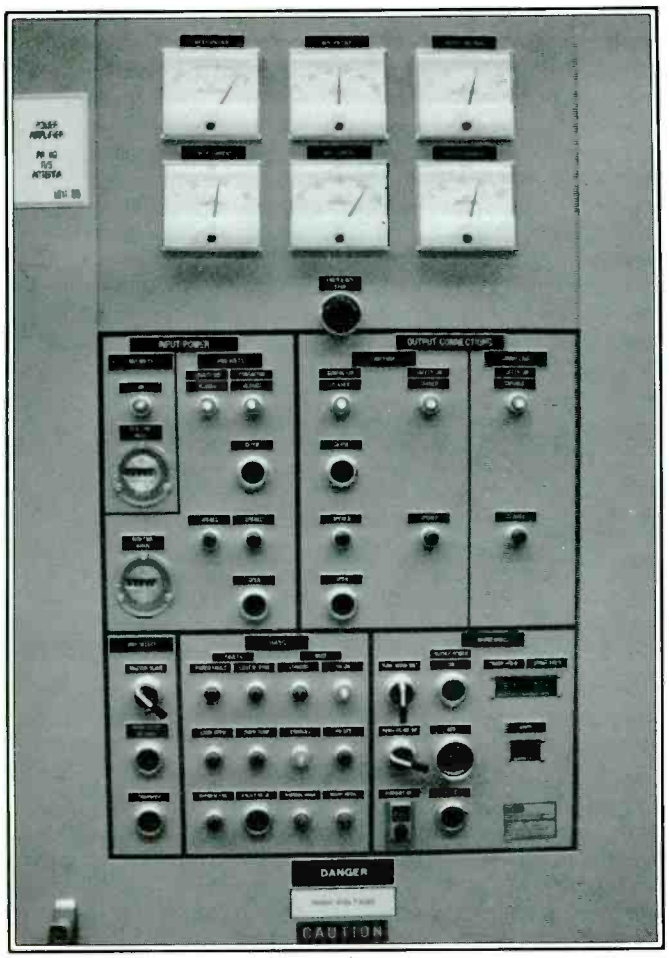
To understand why Project ELF has such strange operating characteristics, let's look at a bit of history and operating theory. Communication with submarines has always been a problem. Radio signals are easily attenuated by sea water. Even VLF transmissions from sources like TACAMO aircraft, NLK at Jim Creek, WA or NAA at Cutler, ME can only penetrate the ocean 30 to 40 feet. To minimize detectability, a submarine must run below the thermocline, a zone of sharp temperature differences that can be several hundred feet deep. The thermocline scrambles audio sounds and confuses sonar detectors.

In the late 1950's, scientific research into the Extremely Low Frequency band (30-300 Hz) turned up several unusual characteristics. ELF radio waves can penetrate sea water several hundred feet, they can travel extraordinarily long distances with very little attenuation, and they are barely affected by ionospheric disturbances like sunspots or nuclear explosions. One scientist, W.O. Schumann, discovered that the earth has resonant frequencies beginning with a fundamental of 7.6 Hz. When the Navy began testing in the early sixties, they chose the 6th and 10th harmonics, 45 and 76 Hz. The results of those experiments established the operating frequency for Project ELF.

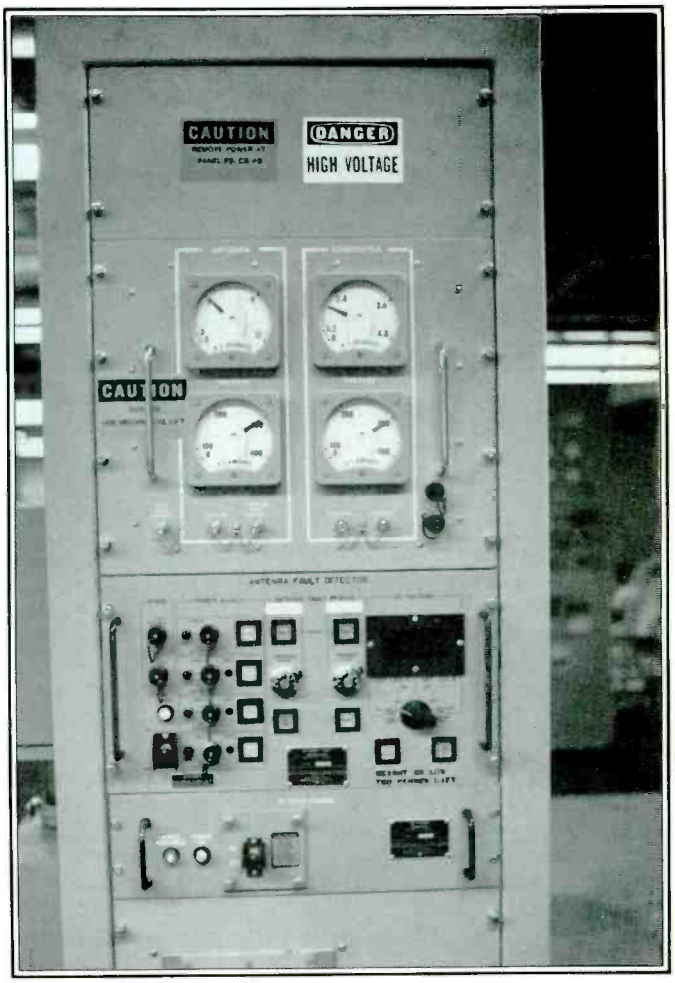
Antenna design at 76 Hz is tricky. With a wavelength of 2500 miles, tuned antennas would have to be enormous. This led the Navy to design Project Sanguine, which had a mammoth transmitter and antenna grid array, covering 40% of the state of Wisconsin. The proposed installation would have had 6200 miles of underground antenna with 100 high power transmitters in hardened bunkers. Political opposition killed the project, but the WTF (then Wisconsin *Test* Facility) continued operation on 45 and 76 Hz well into the 1970's.

In 1975, the Navy proposed a scaled-down version, Project Seafarer, with 2400 miles of antenna in Michigan's Upper Peninsula. Political opposition also scuttled those plans.

Project ELF incorporates a small portion of the Seafarer grid and an extensively up-



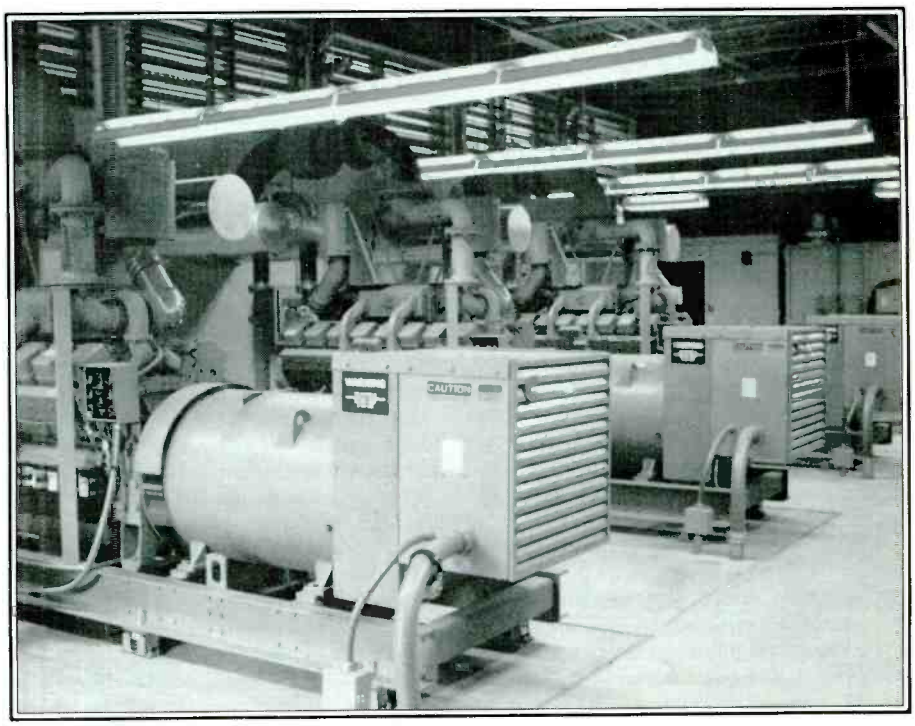
N-S power amplifier control panel.



E-W antenna monitor and fault detector.

dated Sanguine test facility. The total antenna length will be 84 miles. Normal operating power will be 2.3 million watts. Advances in receiver technology and signal processing will make up for the lost size. Because the antennas are a tiny fraction of a wavelength (like using a pin for a CB antenna) they are horribly inefficient, only 2 to 3 watts of RF leaves the antenna. Fortunately, at 76 Hz, a few watts can almost circle the globe and penetrate well into the ocean. Though exact data is classified, Navy spokesman say that ELF signals can be received "hundreds of feet" under the ocean. Messages have been successfully decoded 400 feet under the Mediterranean Sea and the Arctic ice cap. A three letter message takes 15 to 20 minutes to decode. There is some trade off of time versus depth, but the extremely low carrier frequency severely limits the maximum data rate.

Strategically, Project ELF's main use is as a bell ringer. It is a one way system, the submarine must surface and establish communication in the conventional HF/VHF bands to reply. It is an oddball system, but the only means the Navy has to contact a deep running submarine. Only a handful of receivers are currently deployed. At $1 million per copy, they are understandably scarce. Still, Project ELF would make a great ute catch, but I forgot to ask if they would QSL.



Generator shed interior, three Cummins 1 megawatt diesel generators.