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★ REMOTE EQUIPMENT INSTALLATION PRACTICES
★ TV SITE TESTING AND MEASUREMENT TECHNIQUES
★ DESIGN PROBLEMS IN TRIODES AND TETRODES FOR HF OPERATION

1949

TV Site Testing and

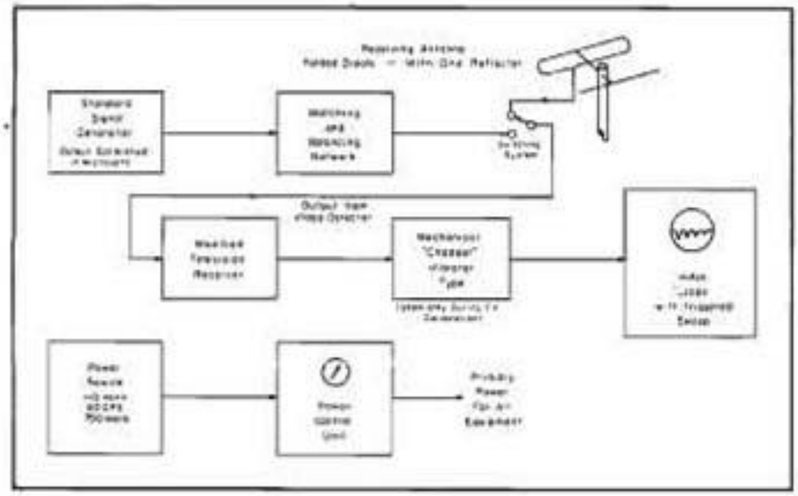


Figure 1
Block diagram of the receiving section of the setup used during the site-testing project.

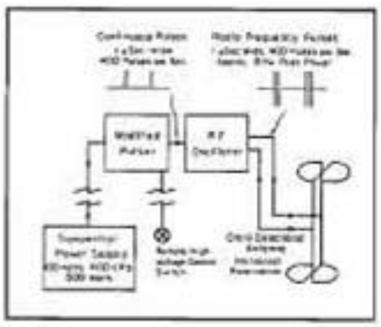


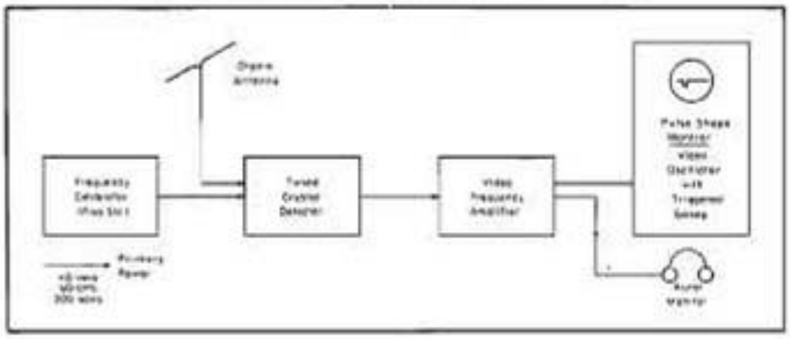
Figure 2
The transmitting section layout of the site equipment. The *rf* oscillator consisted of a pair of push-pull VT127s.

ONE OF THE MAJOR problems confronting prospective television and FM stations is the proper selection of an antenna site. In many instances there is only one really good site available; i.e., the top of the tallest building or nearby hill. It is generally not necessary to invoke the use of site testing methods to affirm this fact. In most cases, however, the solution is not so simple. The community may offer a number of possible locations, all promising, but none outstanding.

What rules apply in making the final selection . . . assuming that the relative cost would be the same for each site under consideration.

Generally, the *line of sight* rule-of-thumb applies fairly well. Height, of course, is extremely important. But, if some natural prominence suitable for an antenna location lies on the *outer* *limits* of the desired service area, it should not be necessary to risk non-uniform coverage and possible attenuation by buildings, trees, etc., to obtain height.

Figure 3
The transmitter monitor section of the site-testing arrangement.



Man-made, as well as *natural* reflecting objects, may send out echo signals over a wide zone, thereby degrading the service from what might otherwise be a good location.

In extremely hilly areas, one particular hill-top location might provide better service in the valleys than other equally elevated locations. It may be hard to prove tthis fact *except* by experiment.

On the assumption that the most accurate method of checking a site is to put a station on the air from the site in question, we can proceed to a consideration of the type of test signal desired:

(*a*) A continuous-wave transmitter could be employed. This would afford information on field intensities, but in general would *not* furnish data regarding echoes, which might be objectionable in television service.

(*b*) Secondly, an actual television station transmitting a test pattern signal offers possibilities, since it would permit direct observation of picture quality and field intensity. This probably would be the ideal technique. The objections to this idea are practical ones. To provide direct data, the station would have to radiate power equivalent to the proposed TV station, and would, therefore, be very nearly as large and expensive. However, this system is still under consideration. The advantages of *direct* observation of quality are obvious. If any receiver installations already exist in the service area, these sets can be used for typical in-the-home observations and demonstrations.

(*c*) Third, a swept-frequency *cw* transmitter could be used to indicate the presence of reflections, but the relative delay of the reflections is not easy to obtain.

(*d*) And finally, a pulse transmitter could be employed. This type of signal will permit observation of field intensity. Using a special pulse receiver with an

Measurement Techniques*

oscilloscope output indicator, by radar technique the time delay between the received pulse and any reasonably long-delayed echo can be observed. Relative strength of the echo can be determined.

The pulse technique seemed to offer the greatest promise, so in our development of a practical system, we selected this approach.

Power outputs in the order of 30 kw (*erp*) are frequently encountered in TB broadcast installations at this time. A small simple pulse transmitter employing radar principles could provide this same order of power. Although it might be possible to compensate for lower test power by added gain in the receiver system, this expedient was not deemed wise. Modern TV receivers approach fairly close to the theoretical optimum noise figure. Therefore, it is doubtful if a receiver could be provided which would allow a justifiable reduction in the test transmitter power. The test should furnish information of coverage in the fringe areas. If the test signal is obscured by noise in these areas, no accurate estimates can be made of what improvements higher power at the transmitter might yield. We, therefore, set an *erp* of 30 kw as the practical goal for our test system, assuming an antenna power gain of two.

The problem of supporting the transmitting antenna of such a site measurement system was quite difficult to solve.

Temporary masts or scaffolding can be used, but if the preliminary tests result in poor coverage, there remains the problem of extending the height of these devices until satisfactory coverage is noted.

Study of Types of Sites and Equipment Which Can Be Used at Test Points, Reveals That Four Types of Transmitters Afford a Means of Checking Before Final Selection Is Made; CW Transmitter, Actual TV Station, Swept Frequency CW Transmitter and Pulse Transmitter. Effective Results Achieved in Typical Setup Using a Hard-Tube Pulse Modulator, Two Coax Loop Transmitting Antennas with a Power Gain of Two, Modified TV Chassis for Pulse Reception and a Barrage Balloon Equipped with Transmitter and Antenna.

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Airborne Supports

An airborne support, if practical, would overcome the above objections. This support might have to operate at heights over five hundred feet above the ground. It would be impractical to have an airborne antenna fed by a transmitter on the ground because of excessive line losses. It is, therefore, necessary that this airborne support provide sufficient lift for both transmitter and antenna. The transmitter primary power supply could be self-contained or power could be fed from the ground.

One of the most desirable characteristics such an airborne support must possess is the ability to hover almost motionlessly for several hours at a time. The only apparatus which has been able to fulfill these requirements has been a well-piloted helicopter. Tests have demonstrated their ability to hover, and they appear to be capable of much better stability than any other airborne test platform. The lifting capacity seems to be adequate in the case of the larger machines. One helicopter operator who uses a Sikorsky S-51, estimates operating costs in the order of $85.00 per flying hour. The main disadvantage of this type helicopter is lack of general availability.

It is possible that in the future more of these machines will be available, which would eliminate the major objection and perhaps lower the cost figure.

The transmitting antenna should, ideally, be equivalent in performance to the antenna which will eventually be employed. This obviously is not practical where small size and light weight are of paramount importance.

An approximation of the ideal case is realized when the antenna used in the tests has enough vertical directivity to eliminate straight up-and-down radiation. Some errors may be involved through using a wider vertical angle of radiation than the final antenna's, but tests have shown fairly good correlation. In general, the lower gain antenna will produce poorer results than the larger stacked arrays, thereby yielding conservatively weighted test data.

On the higher bands, two stacked loops seemed to give the desired pattern with the simplest antenna layout. On the lower bands, the loops were hard to construct, so stacked turnstiles were employed. Other configurations might well be used to achieve the same results.

The receiving setup should, of course, be mobile, to facilitate rapid surveying of a large area. It should be possible to make measurements while in motion. Communications between the transmitter control point and the mobile units would be a desirable, but not a necessary feature. To

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Figure 4
A test pattern taken from WCAU showing the distortions caused by echoes.

facilitate a rapid survey, if costs per unit time are considerable, multiple mobile units may permit a cost saving. For this reason, low cost and generally available standard equipment should be employed wherever possible.

The receiving antenna could be a fairly elaborate affair with extreme directivity to permit analysis of direction of arrival of echoes, or, to expedite observations while in motion, it could be relatively non-directional. Opinions differ on the best approach to this problem. The antenna height should be such that mobile operation can be used, but it should also be possible to extend the antenna to a standard 30-foot elevation to make direct measurements at this height.

Unfortunately, few of the commercially available field intensity meters are suited for measurements on a pulsed signal. However, the requirements are such that an improvised set-up can be made using standard components. A wide-band receiver with a pulse detector and pulse observation 'scope can be used as the receiving and indicating system, and a standard signal generator can be used to standardize the receiver sensitivity. Calibration of the entire system, including the vehicle and antenna may be made in the usual fashion in a standard field of known intensity.

The techniques of pulse observation are fairly well known. A standard *synchroscope* can be used to observe the nature of the principal pulse and subsequent echoes. Delay lines permit observation of the full pulse length. Sweep rates can be chosen to display echoes to advantage.

Recording System Problem

Due to the complexity of the information to be recorded, signal intensity, number and importance of echoes, geographical location, etc., the recording system poses a serious problem which has not been completely solved. Photographic records with marginal notations seem to offer the best solution. It is not too difficult to arrange a system to record peak signal voltage on the usual chart recorder, but this often does not provide adequate information.

We have, up to this point, determined the *nature* of the elements which will comprise our measuring system. We have rejected some obviously unsuitable arrangements. We have made some arbitrary selections of the remaining choices. We have planned a system which, we believed, required no radically new or untried techniques, and which would be assembled from components presently available. Now let us probe the manner in which we applied the principles and the amount of success achieved during field tests.

Test Transmitter

The test transmitter, designed to produce a 1-microsecond pulse at a recurrence rate of 400 *pps*, and a peak *rf* output of 15 kw was built around a hard-tube pulse modulator.[1]

The *rf* section of the transmitter consisted of two triodes (VT-127) connected in a push-pull, tuned-plate tuned-grid, grounded-cathode oscillator circuit. Preliminary tests showed the feasibility of this circuit on channels 2 to 13. Our tests were made on channel 13; somewhat better performance could be expected on the lower channels.

The transmitter was operated from a 400-cycle single phase 110-volt power source and consumed approximately 500 watts.

The pulse-rate was controlled by the main power line frequency, approximately 400 *pps*.

The oscillator was designed to feed into a balanced two-wire *rf* transmission line of 300-ohms characteristic impedance.

Figure 6
Miles Brown, who headed the field expeditions during the site project, at the controls of the test and measurement equipment in the truck.

Figure 5
An undistorted WCAU test pattern.

The unit was housed in a light cylindrical protective container, and had a total weight of about 58 pounds. Its design permitted hanging from a rope support or resting on a flat surface.

The 400 *cps* main power supply was derived from a rotating machine which required 220 volts 3 phase to drive its motor unit. A rectifier power supply supplied the required *dc* for the generator field.

Transmitting Antennas

The antenna used in our tests, designed for channel 13, consisted of two coaxial loops, each one wavelength in circumference spaced approximately one wavelength. Its calculated power gain was two.

The antenna which weighed approximately 2 pounds, could be suspended from a rope harness or clamped to a horizontal boom for rigid support.

Neither the transmitter nor the antenna were designed for all-weather operation, although after exposure to the elements for a reasonably long period of time successful operation was achieved, provided the units were allowed to dry before applying full power.

Receiving Antennas

The receiving antenna was quite simple, consisting of a folded dipole and one reflector spaced ¼ wavelength.

Means were provided for supporting the antenna 12' above the ground for continuous mobile operation, although the mast could be extended to a height of 30' if desired. Rotation from the truck at either elevation was also provided.

Antenna termination box provided means for feeding two receivers from one feed line, an attenuation of about 5 to 1

[1]MIT type 3, available in limited quantities from war surplus.

in voltage resulting when this branching circuit was used.

The pulse receiver was a modified television chassis, using only the picture channel up to the video amplifier.

A variac and voltmeter provided means for maintaining the line voltage at a constant value.

The video circuits were compensated to match the input circuit of the pulse 'scope.

A *chopper* relay was provided to supply a zero-output base line to facilitate gain measurements using a *cw* input signal and an 'scope output indicator.

The picture receiver was a standard model.

The pulse observation 'scope was operated in the *triggered sweep* position, a delay-line built into the 'scope permitting observation of the entire pulse. Minor modifications were made in the intensifier circuit to produce a brighter trace.

A standard signal generator was included to facilitate calibration of the receiver sensitivities. A terminating resistor and an *elevator* transformer was used to transform from the unbalanced low impedance of the generator to the 300-ohm balanced inputs of the two receivers or the branching network.

A telephone circuit was provided between the operator's position and the driver's seat in the truck cab.

The Tests

Our test consisted of mounting the transmitter and antenna from a barrage balloon[2] inflated with 3,000 cubic feet of helium and allowing it to rise 250 feet. The transmitter power was supplied by a ground power supply connected to the balloon with a pair of light insulated wires. Several days were spent in checking the transmissions by means of the mobile receiving unit. It was found that the balloon, in the presence of a light breeze, would not remain in one position for any predictable length of time. This shifting in position and altitude of our transmitting antenna resulted in wide variations in received signal level. The balloon was accordingly discarded as a suitable antenna support.

During these tests, however, we had become familiar with the operation of the equipment and satisfied that it showed a reasonable amount of promise. Our next step was to correlate our measurements against a known TV signal.

Accordingly, arrangements were made to use the facilities of WCAU-TV in Philadelphia. Our test transmitter and antenna were mounted on the WCAU-TV tower in the center of Philadelphia at a point 725' above the street level and approximately 60' below the center of the WCAU-TV antenna. In general, the field strength from our test setup on channel 13 was found to be roughly 70% of that from WCAU on channel 10.

Three Test Runs

Three test runs were made on as many radials. The first run was from WCAU to the Philadelphia Airport.

At the airport, both WCAU and our transmitter produced about 60,000 micro-

[2]War surplus type M-1.

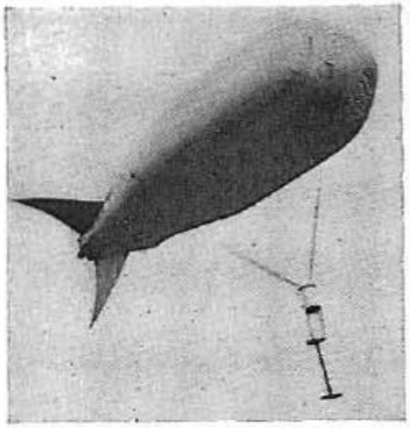

Figure 7
A view of the pulse transmitter suspended from the blimp during a typical test in Camden.

volts on the antenna feed line with the antenna 12' above the ground. This signal was sufficient to overload the television receiver when the feed line was connected directly to it. The airline distance was about 6 miles, and excellent pictures were observed at this particular location. No echoes were noticed even while rotating the antenna, a clear steady picture being maintained even while driving the truck at high speed along the highway. In some obviously poor receiving locations echoes were noted and excellent correlation was observed between the picture and pulse presentations.

Two observers were used, one checking the picture and the other the pulse. In almost every case, simultaneous shouts of *echoes* were heard when a poor location was encountered. No serious transmission faults were noted on this run.

The other radials chosen extended from Philadelphia northwest to Norristown, Pennsylvania, and from Camden to Princeton, New Jersey. Good correlation between both signals were the general rule, and no serious differences were noted.

A trip was made to the region near Wyncote, Pennsylvania, from which several complaints about echoes had been received.

The particular address which was first investigated showed that the complaints were justified. The section is shielded from the line-of-sight path to WCAU by a relatively high hill, and across the valley a higher ridge of hills receives the signal more-or-less directly. Signals reflected from prominent objects on the higher hill arrive at the Wyncote section with an intensity comparable to the main signal.

Figure 8
Closeup views of the equipment used during the tests: pulse receiver, slightly modified TV receiver and the 'scope.

Echo Problems

Several pronounced echoes were apparent. Although the intensity of the echoes relative to the main wave varied widely with the position of the receiving antenna, it would have been difficult to pick a location where an acceptable signal could be received. With our antenna extended to 30', the situation improved somewhat, but even under the optimum conditions picture quality was somewhat degraded.

The pulse measurement showed very close correlation with the picture observations. The direction and distance to the major reflections could be estimated with a fair degree of accuracy.

To check this determination, a run was made toward the echo source, following the antenna bearing indication.

As the mobile receiver approached the hills on the opposite side of the valley, the separation of the echoes and main pulse became less, and we finally arrived at a group of three large water tanks, each of which was responsible for a major echo. Other objects were also producing echoes, but the three tanks were the principal offenders.

In the region around the tanks, echoes were still serious enough to cause relatively poor pictures in spite of the increased strength of the main pulse.

Pulse Test System Results

The tests conducted to date seem to demonstrate the essential practicability of our proposed pulse-test system. Our experimental model has not been developed to the extent where it could be considered a commercial product. It was not our objective to develop such a product, but rather to prove that the equipment could be constructed and employed to provide propagation data under actual field conditions.

Our experimental setup gave reasonably good qualitative data. A trained observer could, by using this equipment, determine correctly in almost every case whether good, mediocre or unsatisfactory service would be rendered. It may well be true that the general lack of precision encountered in *uhf* propagation measurements will introduce so many important errors that further refinement of the measuring equipment is not justified.

Use of Test Data

It must be remembered that the data furnished by a preliminary check are not intended to supplant data taken during a final field strength survey, made on the completed installation. They are merely used to indicate approximately what results should be expected.