(Abstract)

A MICROWAVE RADIO SYSTEM FOR PIPELINE USE

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In the Texas-Illinois pipeline installation of a microwave relay, the reliability problem was emphasized by the distribution of some 2000 vacuum tubes and associated other components over more than a thousand miles of pipeline right-of-way. The general solution to the reliability problem was threefold, including the design of inherently reliable equipment, provision of full automatic switchover to standby in case of component failure, and special test facilities for rapid isolation of any degraded component.

It may be considered that the characteristics of the system, rather than its components, must continue in operation with utmost reliability. In the broadest sense, these characteristics are no characteristics at all; that is, each span and its repeater should appear to the signal as being perfectly linear, lossless, and shielded. This "lack of characteristics" is approached through the utmost simplicity of design and installation.

Just as the best characteristic is no characteristic at all, so the most important designs are those which were designed out of the equipment rather than into it. In the remainder of this abstract, we will consider 3 main items that were designed in terms of the non-essentials which they could delete.

Multiplex System

For some time it has appeared almost a matter of pride that each manufacturer utilize a different kind of modulation technique, roughly half of these being a pulse technique and the other half being frequency-shared CW. In the interest of extreme simplicity, the present design is an entirely CW system; it is believed that this system benefited appreciably by designing out all pulse modulation with related synchronizers and special techniques for pulse handling and pulse testing. This system boils down to double-FM subcarriers; each is CW frequency-modulated by an intelligence, and each in turn contributes to the voltage modulation of the klystron transmitter. Thus, any subcarrier channel may be removed or replaced at will without influencing the functioning of other subcarrier channels. Present designs utilize 24 subcarrier channels, each of which may be further CW multiplexed to carry numerous slow signals such as teletype, telemeter or remote control.

Passive Reflector

In this system, every station that needs a tower for obtaining line-of-sight clearance contains a passive reflector on top of the tower. It is installed at an angle of 45° to the vertical, is illuminated from below by a 40" paraboloid, and is so sized and curved as to optimize the microwave beam which leaves it horizontally. By this means, we have designed out the tower transmission line, along with its flanges, "bullets", weather-seals, pressurizing system, and standby facilities for the pressurizer. This also "designs" the human beings out of the tower system, and eliminates the damaging of tower-mounted gear by target practice (most of the antennas are hidden by a ramp on the shelter). At the various frequencies between 5900 and 8000 mc., the beam width from the paraboloid is on the order of 3.5°, and that emerging horizontally from the passive reflector is on the order of 1.5°. The writer knows of no failures of this technique due to natural phenomena such as hurricane or icing.

In deleting the tower transmission line and pressurizer, we also use an open-air technique for the waveguide and antenna circuit so that customary weather-seals and pressurizing are eliminated from the entire system. The antenna feedhorn aperture is actually wide open, and in contact with the surrounding atmosphere, yet has never been known to fail.

Klystron

A third major selection in the basic design was the klystron transmitter. It completely eliminates the otherwise customary quartz crystal and multipliers, along with their details of contact fingers, corrosion, plating, and adjustments. Because the klystron is readily temperature compensated, and is mounted in an elementary constant-temperature chamber, its frequency is easily within FCC limits. The low efficiency of the reflex klystron is not a handicap; this efficiency, divided into the required output of only 0.1 watt,

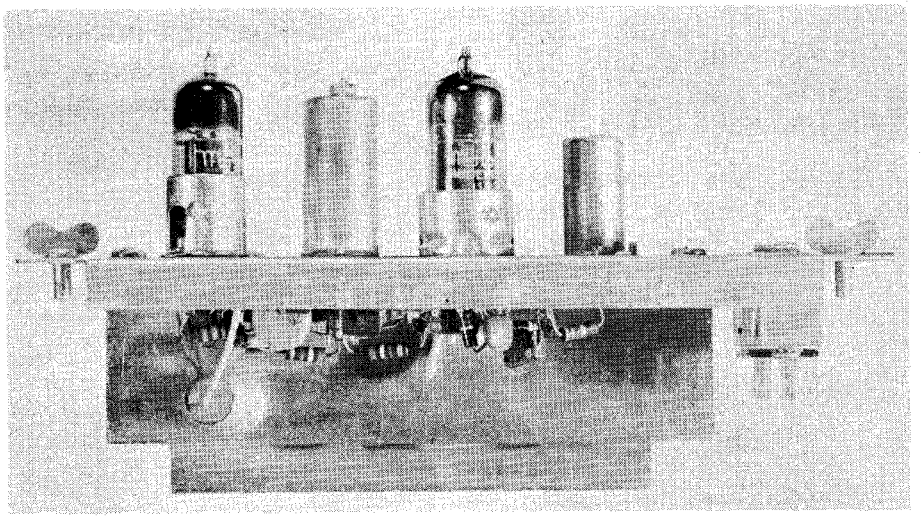
obtains such a low input power that ordinary receiver-type power supplies are used, thus eliminating the bulk and complexity of the high-power supplies. This low-power technique also completely eliminates blowers and the customary indicator and alarm for failure of the blower. The modulation of a reflex klystron is practically voltage-controlled, eliminating the power amplifier type of modulator.

The reflex klystron is such a remarkably clean and simple design that its life is, to the best of the writer's knowledge, greater than any other form of vacuum tube. For example, it avoids the cathode stress of a magnetron, the high voltage stress of certain other modern oscillators, the close and critical spacings of the UHF triode, and the maintenance of any magnet. Such simplicity has obtained an average life exceeding 40,000 hours, which is superior to most vacuum tubes, (and especially to the tower lights). Design details of the system have been published[1] previously.

Conclusion

Reliability has been correlated with the eliminating of non-essentials. No component can be considered essential merely because of previous popularity or frequent prior usage by excellent designers. Mentioned examples of non-essentials that have been eliminated from this product are long transmission lines, pressurizing systems, coaxial circuitry, multiplier stages, blowers, power modulators, and pulse circuitry.

[1] "Design Features Of A Microwave Relay", Ed Dyke, Motorola Incorporated, Tele-Tech, December 1952 and January 1953.



Subcarrier transmitter for simplified CW multiplex system.

Fig. 1

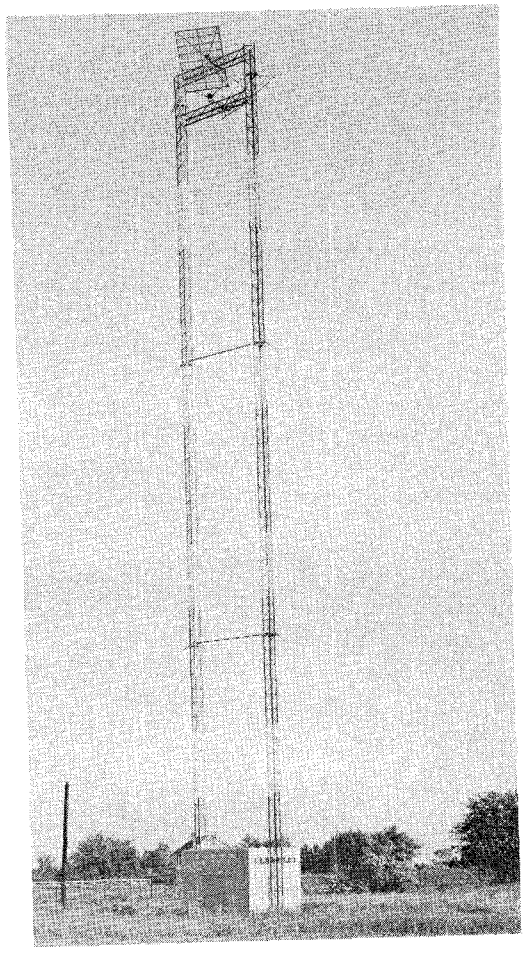


Fig. 2 - Texas-Illinois Gas Company Microwave Repeater Station. Parapet surrounds roof-mounted antennas.

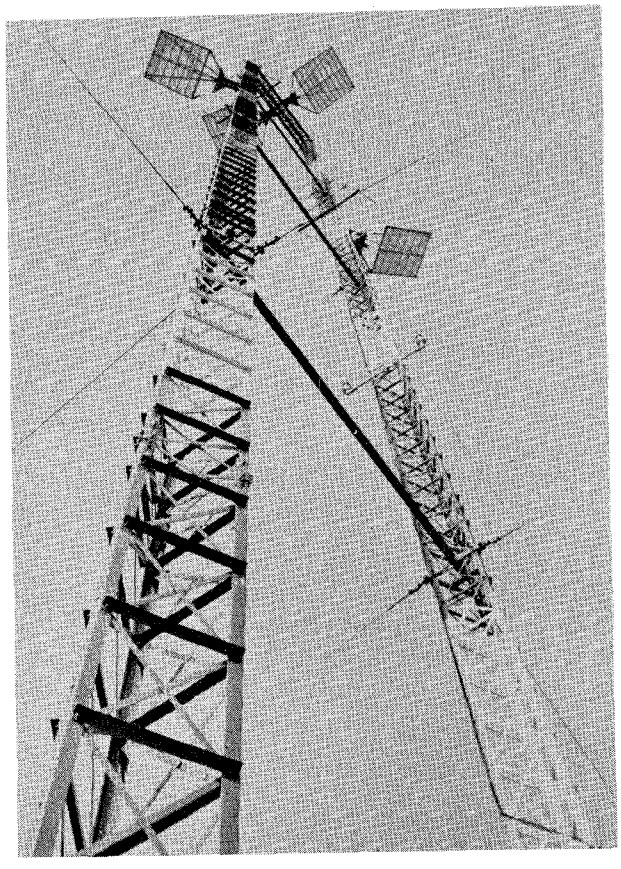


Fig. 3 - Passive reflectors eliminate transmission lines.

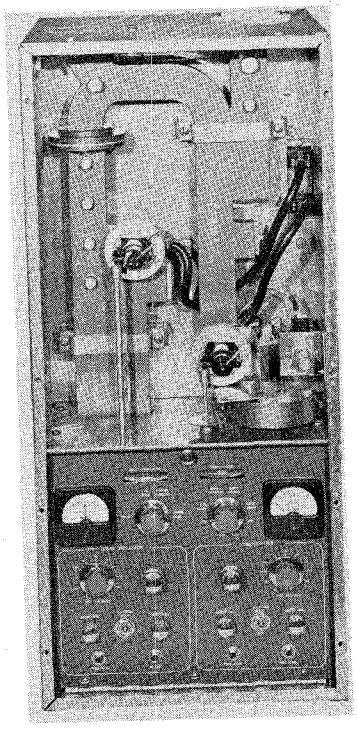


Fig. 4

Waveguide and klystron for receiver (left) and transmitter (right) obtains simplified microwave design.