WLW, AND SUPERPOWER.

Mike Worst has written this article about the development of the 500 kw. transmitter that WLW-700 used in the '30's. Information was taken from Proceedings of the Institute of Radio Engineers, Volume 22, Number10, October 1934. It was quite an achievement then, and certainly an interesting story today.

On May 2, 1934, WLW put a 500 kw. transmitter into regular service. WLW had always been the first to increase power to successive levels. Crosley Radio Co. had filed with the FRC in May 1932 for an increase in power from 50 to 500 kw., since it was felt that any lesser increase would have shown relatively small improvement; a CP had been issued the following month. The 50 kw. transmitter was to be used as the driver for the 500 kw. transmitter.

The total cost of the improvement was about $500,000. The annual cost of operation and maintenance was set at $170,000, for a 20 hour broadcast day. The use of high level class B modulation provided a power saving of $25,000 yearly.

For economy of both cost and maintenance, the power amplifier was divided into 3 units and the modulator into 2 units so that a failure wouldn't take the whole transmitter off the air. There were a total of twelve 100 kw. power amplifier tubes and eight 100 kw. modulator tubes. All tubes operated at a plate voltage of about 11,800 volts. If a short occurred, the transmitter automatically went off the air for 4 cycles, then went back on the air. If the short persisted, the transmitter again went off and the defective power amplifier unit was automatically cut out and the remainder went back on the air with about 350 kw. The entire off-air time rarely exceeded 3 seconds. If a modulator went out, the transmitter went back on the air after several seconds with full power but with reduced modulation. The 4 power amplifiers and 2 modulator units could be used in almost any arrangement. The power was supplied by two 33,000 volt lines from 2 different distribution centers and came to the transmitter over widely separated routes.

The transmitter was made as an integral part of a building with 5 separate rooms. Each room was entirely shielded as a unit and rooms were electrically bonded at numerous points. The problem of radio frequency insulation made a new style of insulator necessary, so GE produced long-bar green-tint Mycalex for this specific application.

The modulation system was unique in several respects: the power required was 10 times greater than ever obtained before from any audio amplifier. The fidelity had to be maintained or advanced, and the output had to have an efficiency as high as possible. Since the modulator stage was divided into 2 units, separate interstage transformers were used to couple them with the previous stage. These transformers weighed over 2 tons each. The modulator stage was then transformer coupled to the load circuit by 2 identical transformers. These transformers were rated at 160 kilovolt-amperes each from 30 to 10,000 cps, and were oil-immersed and weighed 19 tons each. The height was 11 feet and the case around each unit was elliptical in shape, having a maximum dimension of 7 feet and a minimum dimension of 4 3/4 feet. The direct current component of the power amplifier plate current was passed through a modulation inductance reactor rather than through the secondary windings of the transformers. The reactor had 4.5 henrys of inductance at 60 amperes, and was similar in shape to the modulator output transformers but weighed only 12 tons (ONLY!).

With an input to the power amplifier of 700 kw., the output of the modulator system required to give 100% modulation was 350 kw. The power input for 100% modulation was 12.5 milliwatts. This corresponds to a power amplification of 28,000,000 times. Current limiting resistors connected in series with the plates of each of the modulator tubes were of such a size to limit the surge current to 1000 amperes or so. The power dissipated in them was 12,000 kw. for a time of about 1/12 of a second.

The radio-frequency amplifier was composed of 3 identical units each capable of delivering 167 kw. of carrier power. The filaments of the amplifier tubes used 33 volts and drew 207 amperes, which made the total filament current for the power amplifiers and the modulator of 4150 amps.

The concentric transmission line (used because it suppresses harmonic radiation) which transmitted the power to the antenna house was 760 feet long. The surge impedence was 100 ohms, thereby making the line voltage 7070 volts at 70.7 amperes for unmodulated 500 kw. The outer tube was 10 inches in diameter and the inner tube was 1.875 inches. It is believed that this was the first application of the concentric transmission line for a broadcast station in the U.S.

The main rectifier consisted of six RCA-870 mercury-vapor tubes rated at 16,000 volts with 450 amps. The average current was 75 amps so they were operated considerably below their maximum rating. Three single phase plate transformers were used, which were relatively light at 7000 pounds each. They were connected so that the equipment could be tested or warmed up at a lowered voltage of 7000 volts. The rectifier could give a continuous output of 1250 kw., but the load was always varying during modulation, so the direct-current load current varied from 70 amps at zero modulation up to 110 amps at 100% modulation.

Bias voltage today is always taken from the power supply or from the output of the preceeding stage, or the circuit can be self-biased. In the WLW transmitter, all bias voltages were supplied directly by DC generators. The generator which supplied bias voltage for the powere amplifier tubes was rated at 1.2 kw. at 1000 volts; for the modulators at 1.2 kw. at 100 volts; and the one for the first 4 audio stages at 0.375 kw. at 1500 volts.

With the power of 500 kw. a special study had to be conducted to decide what type of antenna would be used. One of 0.59 wavelength was the best practical type known at the time, which at the frequency of 700 kc. worked out to be 831 feet. The widest part, 35 feet across, was at the 350 foot level (where the WLW neon sign was). The tower rested on a single porcelain base insulator and was held by eight 2-inch guy cables, which were broken up with 7 insulators. The tower was put into use in June 1933 with the 50 kw. transmitter, and by comparing the operation of the T antenna that ahd been used for years, it was found that the effective power had been doubled for this particular operation. (The T antenna was at 0.75 of the fundamental frequency). In some areas, it was found that the nonfading service had increased 66%. This was nothing, though, compared to when the 500 kw. finally went on.

The first equipment arrived about July 1, 1933, and on November 1st 500 kw. were put on the air. Within a few days this was substantially increased with 100% modulation. The planning had been completed many months before the installation, so no major changes had to be made during construction. The normal output power was 525,000 watts. The normal power input to the power amplifier alone was 1150 kw. for zero modulation, 1600 kw. for 100% modulation, and 1225 kw. for normal average modulation. The frequency characteristics at 50% modulation was one db low at 30 to 50 cycles, ½ db low at 150 cycles, zero db to 5000 cycles, ½ db low at 8000 cycles, and two db low at 10,000 cycles, using 1000 cycles as zero db. 100% modulation was obtainable at all frequencies between 30 and 10,000 cycles.

With a fundamental field strength of 6 volts per meter at one mile (note that this is 6 million microvolts per meter), the strength of the strongest harmonic (the second) was 400 microvolts per meter at one mile. This is equal to 0.002 watt. The 4th harmonic didn't exceed 200 microvolts , and the 3rd, 5th, and 6th were below 50 microvolts. At the time these characteristics were believed to be in advance of the requirements of the broadcast art, and in general was at the greatest degree of excellence that was economically justifiable.