Several types of $\frac{1}{4}$- to $\frac{1}{2}$-megawatt triode tubes have been developed with the tuned circuits inside the vacuum envelope. By the close of the war, triode oscillator tubes had been developed which gave approximately 0.6 megawatt up to about 700 megacycles. Power-amplifier tubes are available that can handle 100 or 200 watts continuous-wave output up to 700 megacycles with a power gain of about 5 decibels.

Hydrogen thyratrons were originated and put into production during the war to eliminate temperature dependence of mercury tubes. These thyratrons handle powers of from a fraction of a watt to 2 megawatts pulse power. Series and/or parallel operation of thyratrons has been accomplished to allow up to four times the power of a single thyratron. Ignitrons have been used up to 2 megawatts at 20 microseconds pulse width. High-vacuum modulator tubes have been developed to handle a few hundred kilowatts peak power at duty ratios of about 0.0006. Tubes of each of these types are shown in Fig. 7.

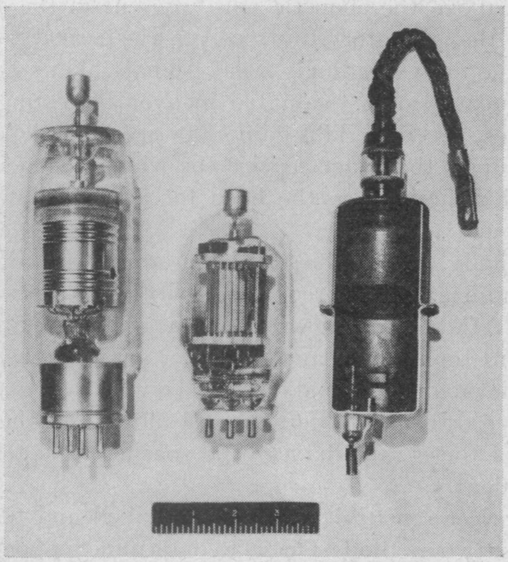

Fig. 7—Pulse modulator tubes: 5C22 hydrogen thyratron; 715C high-vacuum type; 1R21 mercury-pool ignitron.

The resnatron, employed during the war in radar countermeasures to jam German radar, is the most powerful ultra-high-frequency oscillator and amplifier now in existence. It supplies over 50 kilowatts in continuous-wave operation at frequencies ranging from 350 to 650 megacycles, with a plate efficiency of the order of 60 to 70 per cent. Features of this tetrode include beam-forming grids, electron bunching, and self-contained resonant cavities which permit phase-shift compensation for transit-time effects without lowering efficiency.

IX. Receiving Tubes

There are so many types of receiving tubes that it is impossible to begin to describe them here. Consequently only a few practices of a general nature that came into considerably wider employment during the war will be mentioned in this section. The use of standard tubes at low plate and screen voltages was accomplished to allow operation directly from a 24-volt storage battery in place of a high-voltage power supply. Subsequently, tubes with 26.5-volt filaments and a design optimized for 28-volt plate and screen operation were developed. Tubes were "ruggedized" to withstand vibration and shock up to 500 times the acceleration of gravity. Subminiature tubes (T-3 bulbs of $\frac{3}{8}$-inch diameter) were in existence before the war for hearing-aid use. During the war, subminiature types for VT fuzes were developed which could withstand being shot from guns. Size and weight limitations of new radar and allied equipment, along with the need for high peak power output, created the need for receiving-type tubes capable of operating in a pulsed condition at potentials and currents far above their rated values. Fig. 8 shows six different types of receiving tubes.

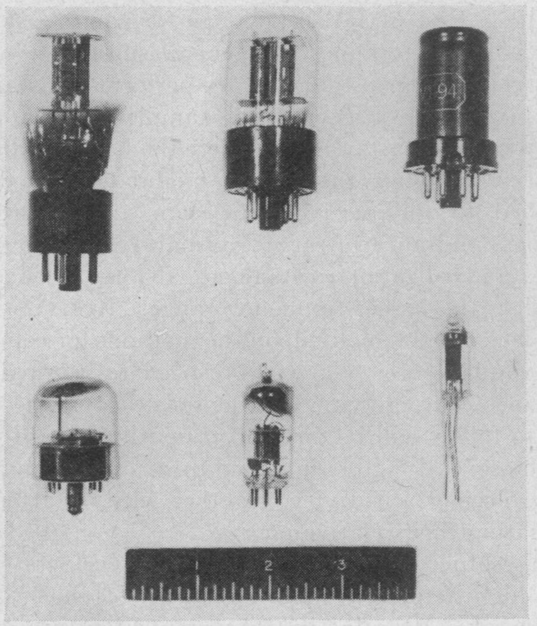

Fig. 8—Receiving tubes having transconductances of 3000 to 5000: G, GT, metal, lockin, miniature, and subminiature tube types 6J5G, 6J5GT, 6J5, 7F8, 6J6, 6K4.

There is now an overabundance of receiving-tube types—one or two thousand, or perhaps more. It is not unusual to find half a dozen or more tubes, substantially equivalent, differing by having several filament voltages, two or three types of bases and bulbs, and different arrangements of pin connections. Almost every metal-tube type is duplicated in a glass version with the same base, and most are also duplicated in lock-in construction under different type designations. Now most of these types are becoming available in miniature bulbs.

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