MACHLETT POWER OUTPUT
HEAVY DUTY ELECTRON TUBES

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Operation and Maintenance— Filament Wire Types

In the last issue of "Power Output" it was noted that the filament wire, heated to incandesence, emits a cloud of electrons and that these are drawn upon by the plate or anode to provide tube current. Three common filament wire types are employed to create the electron cloud: oxide coated, thoriated and pure tungsten wires. Oxide coated filaments are normally restricted to receiving tube types and the latter wires are typically used in large industrial or broadcasting tubes.

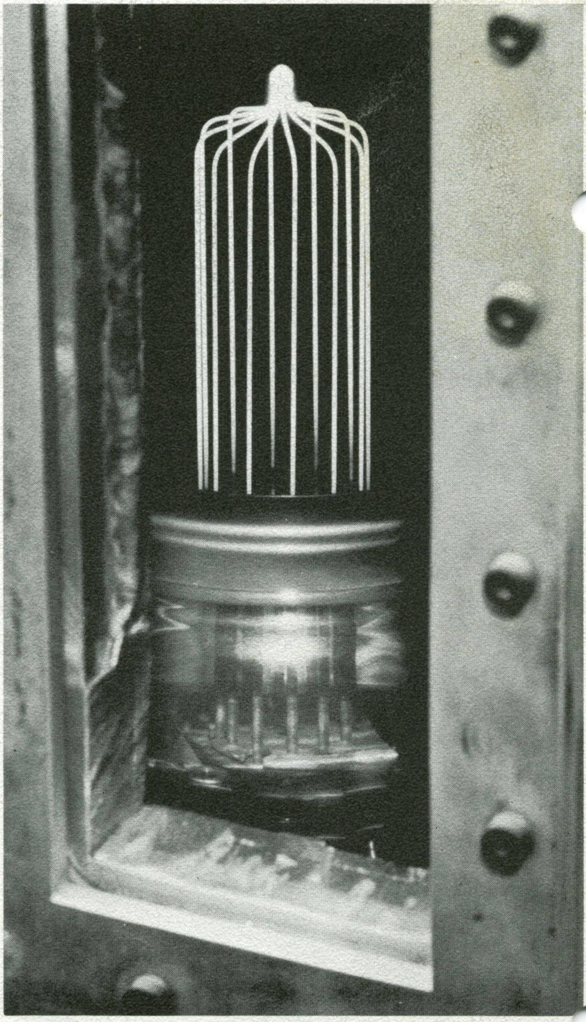
The efficiency of the filament depends on the power required to produce a given emission of electrons. Most industrial tubes of recent design incorporate thoriated tungsten wire filaments since the pure tungsten filament requires about twice the power for a given emission level. Thoriated tungsten tubes also have an appreciably longer life than do those using pure tungsten wire, when both are operated at rated power.

Pure Tungsten Wire

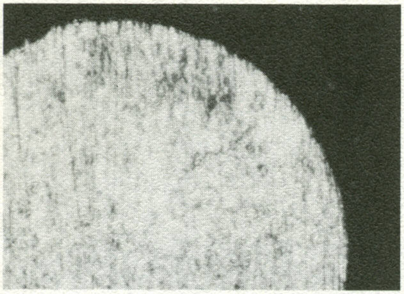
An electron is about one third of a millionth of the weight of a tungsten atom. When the pure tungsten filament wire emits electrons it also "boils off" tungsten atoms. The rate of tungsten boil-off is dependent on the wire temperature. When sufficient atoms have been removed to reduce the wire diameter by about 10% the wire usually becomes excessively hot at some point and rapidly burns out, causing an open filament.

Thoriated-Tungsten Wire

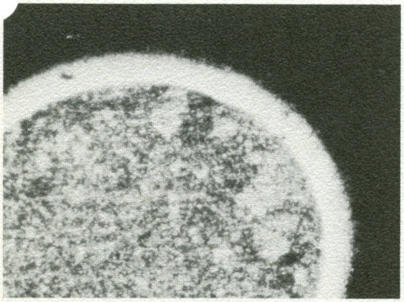
This is a more complicated wire material to manufacture and process, but offers in return higher current densities and longer life (at rated output). Any tungsten wire begins as a tungsten powder



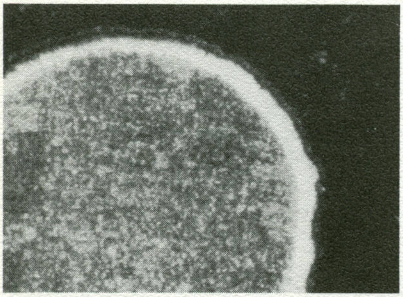
Thoriated-tungsten filament in carburizing bell. Each filament is processed to prolong life.



Cross-section of thoriated-tungsten wire prior to carburization.



Cross-section of thoriated-tungsten wire following carburization.



Cross-section of thoriated-tungsten wire nearing end of life. Depletion of carburized layer is evident. Loss of emission follows complete depletion of layer. Filament diameter remains approximately the same.

which is sintered into wire form and then drawn to size. To make thoriated-tungsten wire a small amount of thorium oxide (thoria) is mixed with the tungsten powder prior to sintering. During the heating of the filament, some thoria is reduced to thorium and it forms a monatomic film of metallic thorium on the surface of the tungsten wire. Thorium reduces the power required for electron emission — thereby increasing emission efficiency.

Early thoriated-tungsten filaments had a relatively short life because of the rapid depletion of thorium from the wire surface. It was found that the depletion rate could be reduced to a small amount by heating the thoriated-tungsten wire in a hydrocarbon atmosphere. The hydrocarbon molecules combine with the tungsten to form a tungsten carbide layer. This layer stabilizes the filament operation, permitting "low" temperature operation (relative to pure tungsten temperatures) and is instrumental in reducing the rate of thorium evaporation. The amount or depth of the carburizing is critical and requires a high degree of manufacturing skill to get uniform results and good, long, emission.

End of life for a thoriated-tungsten filament occurs shortly after the tungsten carbide layer is depleted. Occurring, normally, after many thousands of hours, this depletion is partially a result of positive ion bombardment* and partially a result of evaporation of the carbide from the tungsten. Since optimum emission occurs only over a narrow temperature range it is neccessary to regulate filament voltage carefully (filament voltage determines filament temperature) to prevent over-rapid carbide loss and to get longest life from the thoriated-tungsten wire. Regulation of voltage within +5% and —10% of rated filament voltage is normally recommended.

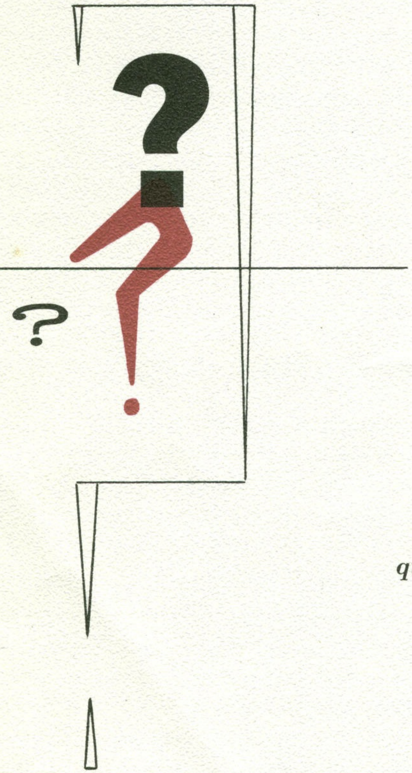
Positive ions bombarding the filament tend to strip

*Molecules, stripped of an electron, become positive ions and are free to travel in the reverse direction from anode to cathode, from positive to negative. Since no vacuum perfect, some molecules will always be found in an electron tube. Collision of high energy electrons, travelling from the cathode cloud to the anode, can ionize the gas molecules found in the tube envelope.

away the extremely thin tungsten carbide layer, or may coat it.** The numbers of ions which appear depend on the internal cleanliness of the tube (a matter to be discussed later). Suffice it to say now — the better the tube processing and cleaning, the better the filament life potential.

**Under certain conditions the emission loss of a thoriated-tungsten tube can be restored. Such emission loss is, however, extremely infrequent.

The thoriated-tungsten filament does not burn out at end of life. The filament remains essentially intact, a pure tungsten wire of a diameter about the same as that of the original thoriated-tungsten wire. Actually, if circumstances permit, a good thoriated-tungsten filament tube can be operated (at high filament voltages) as a pure tungsten tube for a certain period of time. Usually, however, this is not economically practical.



question: Terminal connectors are sometimes hard to remove, is there a remedy for this?

answer: Yes. Conventional terminal connectors "freeze" to the terminal post after prolonged use. Machlett terminal post connectors employ heat dissipating fins to permit cool operation, and minimize "heat freezing".

For removal the Machlett terminal post connectors provide a jack screw (center screw on the connector) to separate the connector flanges prior to connector removal. This center screw should be backed off prior to installation of the connector.

Induction Heating Versatility at —

Sikorsky Aircraft

Hovering a few feet off the ground a Sikorsky S-55 sits for its portrait.

The term "helicopter" is synonymous with the Sikorsky name. Pioneer in this unique form of air transportation, and one of its foremost exponents, Sikorsky Aircraft, Division of United Aircraft Corp., is today the largest manufacturer of the helicopter. Modern methods of manufacture, including the use of vacuum tube induction heating equipment, have been of first importance in this development.

An extremely exacting machine to design and manufacture (compare the number of helicopter designs with fixed wing designs over the past two decades), its uses are nearly without limit. These single rotor craft, in addition to the routine work of passenger and cargo carrying, have served as aerial tugboats, pulling disabled ships; have made the difference between success or failure in innumerable rescue missions; and have performed urgent military tasks of many sorts. New fields of activity now await the helicopter — in one of these a new Sikorsky flying crane, which can haul tons of material aloft, will permit acceleration of heavy construction in remote or inaccessible areas.

Sikorsky helicopter's position derives in part from the reliability of transmission machinery, including drive shafts. Light, but rugged, helicopter transmissions must provide all basic flight controlling functions as well as the transmission of power. Induction heat has proved invaluable for the achievement and maintenance of high standards of safety for certain of these components.

The helicopter rotor may be considered as a rotary multi-membered wing. Although the motion of the rotor blades is highly complex, their fundamental purposes are relatively simple — to lift the craft, create forward motion as well as those motions necessary for banking or turning the craft. In performing these functions the rotor blades exert a strong torque (changing with rotor speed) for which a counter torque must be provided. Without the counter reaction both rotor and craft would tend to spin together about the vertical axis. To prevent this, that is, to stabilize the craft around its vertical axis, and to help steer, a "torque propellor" is employed. Blade pitch (which controls the effect the propellor creates) is adjusted by the pilot's rudder pedals. The propellor is driven, on the Sikorsky S-55, by a long shaft connecting it to the center drive of the helicopter. The torque propellor drive shaft (which is subject to considerable stress during operation) is a highly important assembly. Induction heating has made a valuable contribution to the strength and relability of this shaft assembly.

In another application a previously slow, inefficient method, has been replaced by a rapid simple induction heat technique. Tubes used for control rods or for structural support require, in many instances, a rounded or domed closure of one end. This had been done by spinning (forming) the tube end in flame heat. Induction heating has speeded the process and has drastically reduced part rejection.

Ingenious Work Handling Devices

Sikorsky applications of induction heat have required ingenious work handling equipments. It is, in fact, the combination of working handling equipment with induction heating which has made these production advances practical.

For example, when gas torches had been used to heat control rod and support tube ends for spinning the rejection rate had been in the order of 25-30%. This rate was a result of the difficulty of the technique, scale formation on the metal, and radial cracks in finished pieces.

It was determined that an induction coil, placed as shown in Figure 1 would provide suitable heat energy for spinning. The coil configuration is such that both steel and aluminum tubing, of a given diameter (½″ to 2″) may be formed without coil

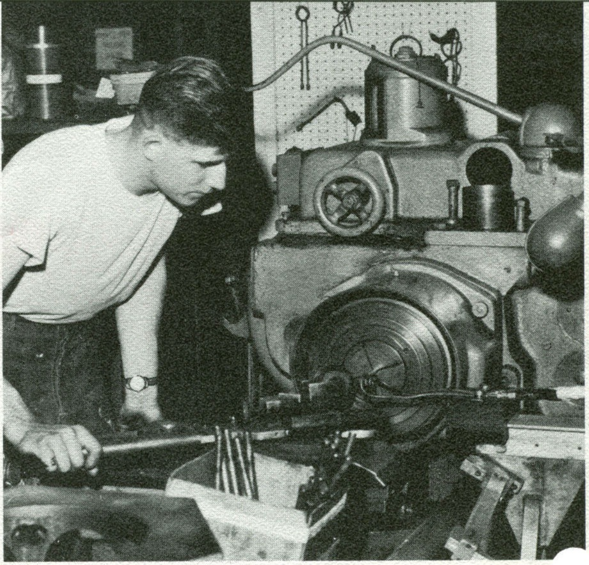


Figure 1

Spinning tube ends with induction heat. Induction coil, positioned next to tube provides quick controlled, heat for the operation. Finished tubing is placed in loose asbestos to cool; tube end is now ready for next stage in production.

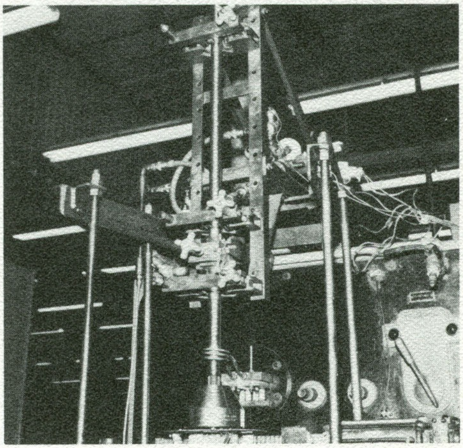
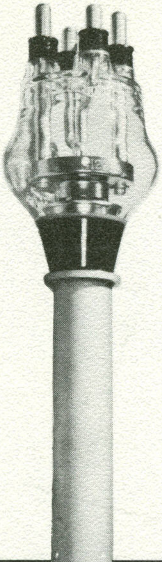
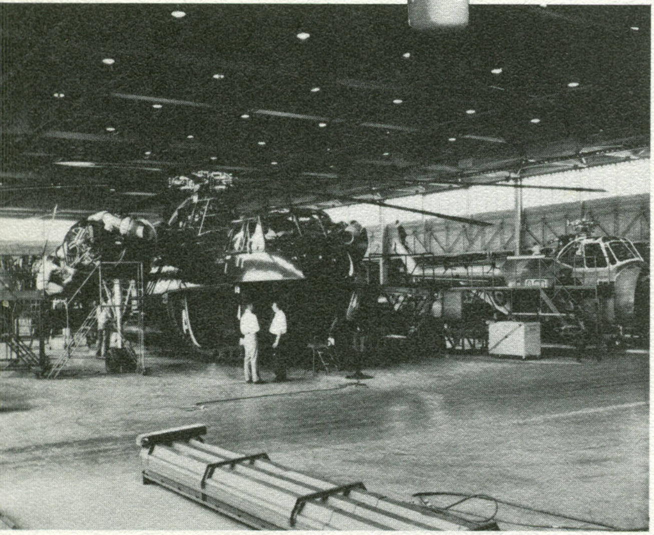


Figure 2

Ingenious work handling devices permit optimum utilization of induction heat. Splined gear (below induction coil) is brazed to torque propellor drive shaft (extending up through fixture, out of picture) by induction heat to provide join of maximum strength.

ML-5606 industrial triode used in induction heaters at Sikorsky Aircraft.





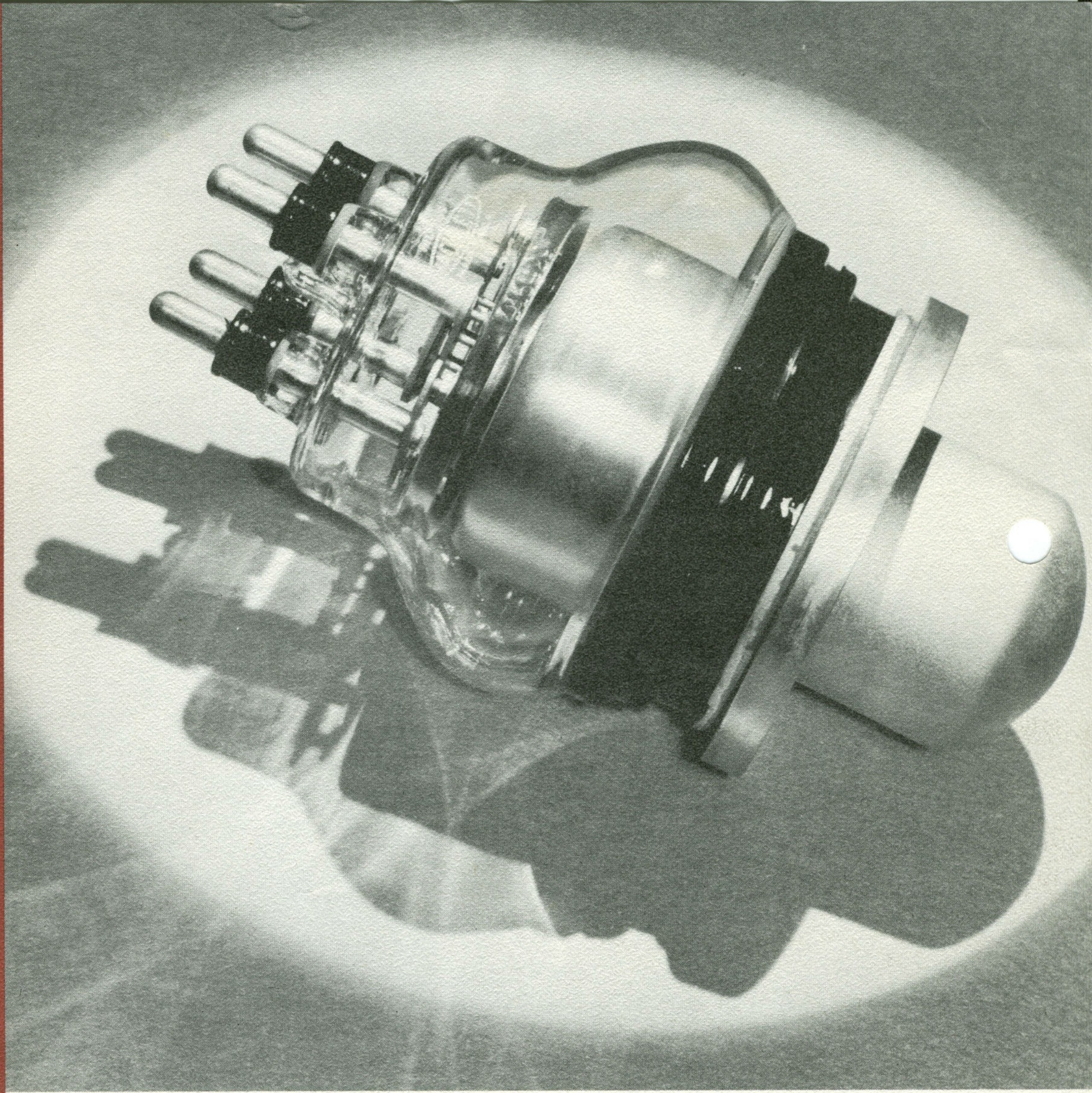
Sikorsky helicopters are assembled at the Company's Stratford, Conn. plant. S-55, right, for delivery to the Belgian Congo region, uses induction brazed torque propellor shaft. All of Sikorsky's helicopters use tube supports and control rods whose ends have been shaped by induction spinning.

change. A spinning tool, mounted on the cross feed of a lathe and adjustable, is easily worked by the operator. Scale formation is negligible; tube polishing after spinning is no longer required. A complete pressure weld closing of the end is accomplished. The radial shape prevents cooling cracks, previous cause of many rejections. Other than ball shaped ends (flattened or pointed) are avoided because of high crack formation.

The tail rotor drive shaft which drives the torque propellor has a splined gear brazed to one end. The gear unit must be brazed to give extremely high joint strength and yet not weaken the shaft. Pre-production shafts were torch brazed, a process which annealed and weakened the shaft. A new approach was made using an air operated fixture in combination with an induction coil (Fig. 2).

The automatic fixture makes a wiped joint, for strength, and, by careful cycling, prevents shaft annealing. The gear shank (brazed to the I.D. of the drive shaft) is heated by the induction coil; immediately afterward the shaft is pushed down on the shank and the braze is made. As the shaft is lowered over the shank the induction coil is de-energized. Immediately after this the air cylinder (which actuates a rack and pinion to turn the gear shank within the shaft) stops the wiping action and the braze is done. Without the precise timing and heat control made possible by the induction coils this operation would be very difficult, if not impossible, to perform. The final result is a shaft having a join whose breaking torque is better than twice that of the torch brazed pre-production type.

These and other production jobs have been ably performed at Sikorsky with induction heating. This versatile tool in these installations employs the Machlett ML-5606 power triode. Designed to give low cost service, the ML-5606 industrial tube design incorporates a sturdy terminal structure using heavy, solid, copper terminal posts. Other advantages over the older type 892, which it replaces directly, include a compact glass envelope and reduced terminal inductance (an aid to circuit stability).



ML-356 Water-Cooled Triode

One of the first heavy duty triodes to incorporate "r-f final seal-in" (a Machlett innovation) the ML-356 provides long service in industrial duty. R-F final seal-in, or radio-frequency final seal-in, is an exceptionally quick method of completing the tube envelope. The seal-in, made by induction heat, completes the envelope in seal in seconds and provides for a clean gas-free tube.

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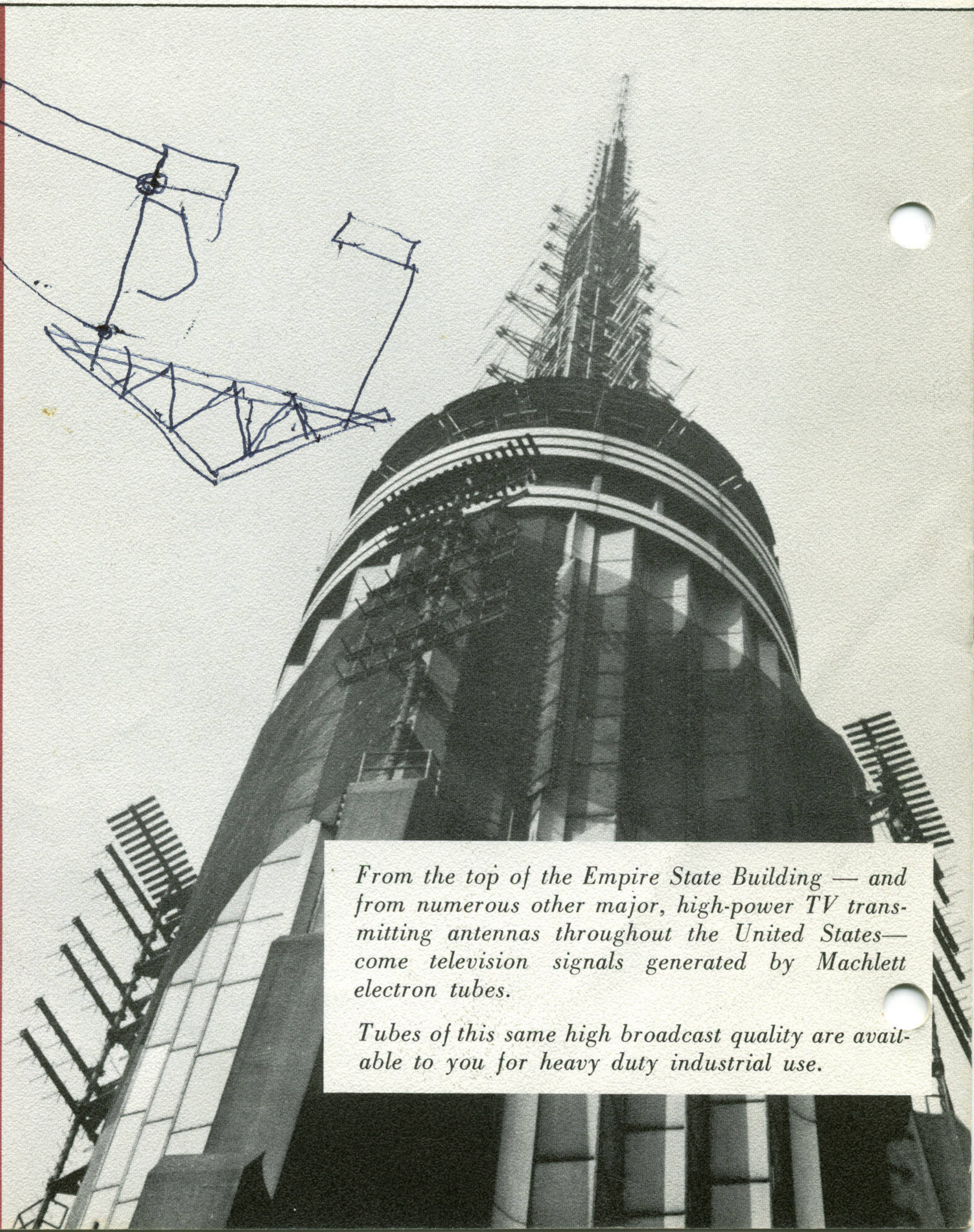

From the top of the Empire State Building — and from numerous other major, high-power TV transmitting antennas throughout the United States—come television signals generated by Machlett electron tubes.

Tubes of this same high broadcast quality are available to you for heavy duty industrial use.

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