TUBE COLLECTOR

TUBE COLLECTORS ASSOCIATION

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TUBE COLLECTOR

TUBE COLLECTORS ASSOCIATION, INC.

PO Box 636, Ashland, OR 97520, USA

The Tube Collectors Association is a nonprofit, noncommercial group of individuals active in the history, preservation, and use of electron-tube technology. *Tube Collector*, its bulletin, appears six times per year.

Officers and Staff

President: Ludwell Sibley, KB2EVN, (541) 855-5207, *tubelore@jeffnet.org*
Vice President: Norm Wilson, N6JV, (916) 689-3534, *N6JV@N6JV.com*
Secretary-Treasurer: Bob Deuel, K2GLO, (541) 482-8752, *k2glo@jkasystems.com*
Editor: Ludwell Sibley, as above
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Web Site: *www.tubecollectors.org*

email Reflector: *tubecollectorsassociation@yahoogroups.com*
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Group moderator: Ron Lawrence, W4RON, *w4ron@carolina.rr.com*

To join TCA: annual dues is $20.00 (in North America; $25.00 elsewhere), to the address above. Please make checks payable to "Tube Collectors Association." Payment by PayPal is welcomed, to *tca@jkasystems.com*. The membership year runs January-through-December. Those joining after February receive the year's back issues of TCA publications. Multi-year membership is invited, at: in North America, $37 for two years or $54 for three; elsewhere, $49 for two years or $73 for three.

Articles on tube topics are welcomed. Editorial correspondence should go to the editor at *tubelore@jeffnet.org* or **102 McDonough Rd., Gold Hill, OR 97525**.

Renewals, changes of address, and other membership business should go to Bob Deuel at *tca@jkasystems.com* or **PO Box 636, Ashland, OR 97520**.

FRONT COVER: "Dan's Used Curve-Tracer Lot" – Daniel Schoo, perhaps better known for heroic radio restorations in the pages of *Antique Radio Classified*, now appears in our pages with a feature on adapting tracers intended for solid-state devices to use with tubes.

Photo: Daniel Schoo

REAR COVER: A colorful Mullard dealer-aids chart from 1951.

Image: Phillip Taylor

MICROPHONICS FROM THE EDITOR

CHARLOTTE PREREG OPEN

This event, comprising the annual antique-radio conference of the Carolinas Chapter of the Antique Wireless Assn., a half-day of meeting of TCA people (and CC-AWA enthusiasts), and the Charlotte International Cryptologic Symposium, will occur on Thursday through Saturday, March 22-24, 2012. Preregistration is now open and welcomed. A printable form, details on the hotel, schedules, etc., are available at http://antiqueradiocharlotte.homestead.com.

TEKTRONIX MUSEUM OPENS

Two years ago we reported plans by a group of former employees of Tektronix, Inc. to establish a museum and library dedicated to the company and its products during the peak years (roughly 1947-86). Well, they've made it happen. The place is now open (currently Fridays and Saturdays) at 4620A SW Beaverton-Hillsdale Hwy. in Beaverton, Oregon. About 350 instruments are on display, many of them beautifully restored to operation. One of the organizers is Stan Griffiths, known for his comprehensive book Oscilloscopes - Selecting and Restoring a Classic.

The organization is a 501(c)(3) charity and solicits donations and memberships. More scoop - including vintage Tek-related videos, photos, equipment lists, and "stories" - is available on www.vintagetek.org.

AWA TYNE AWARD COLLAPSES

The Antique Wireless Association has offered an annual award, named in honor of author G. F. J. Tyne, since 1980. The first recipient was Bro. Patrick Dowd, but a long line of other luminaries have received it.

It fell apart this year. Members were invited, via the *Journal*, to send nominations to the long-standing administrator. Trouble is, said administrator had just resigned. There was some finger-pointing and confusion over a possible replacement. However, nobody in AWA management stepped in to appoint an interim administrator or to alert members of the change via the member email reflector. So the thing fell on its face.

Unfortunately, a nomination was in hand for a highly qualified individual to get the 2011 prize. It is singularly disappointing to see this award blocked by managerial bumbling.

The AWA Web site still invites nominations to be sent to the resigned administrator!

IN THIS ISSUE

TUBE MANUFACTURING AT TUNG-SOL IN THE 1950s

Stephen Kalista

From *Radio Age* (Mid-Atlantic Antique Radio Club), August 1994. Reprinted by permission.

I worked at the Tung-Sol Corp. in Bloomfield, NJ, in the 1950s as a tube development engineer. Here are a few of my recollections about that experience.

To enhance electron emission, Tung-Sol sprayed the tube cathodes with "triple carbonate" during the processing. (Unfortunately, I can't recall the chemical composition of this spray.) After the new tubes came off the assembly line, they were put on an aging rack for burn-in. The first step was to activate the cathode. This was done by raising the filament voltage to approximately double the rated voltage (i.e., a 6.3-V filament tube would be elevated to 12.0 volts for a period of from 30 seconds to one minute).

The other voltages (plate, screen grid, etc.) were applied for various periods of time to further activate the cathode and stabilize it. After that process, a sample was life-tested for 500 hours. If tubes were for military use, they were vibrated, dropped, etc.

The process of tube making was less scientific than you might expect; at least that was the case at Tung-Sol. Recipes were a little like Grandma's cookie recipes -- a pinch of this and a dash of that. There were no good text books available that described tube optimization, and companies like Tung-Sol were careful to protect their trade secrets after they stumbled upon a process that worked following a period of trial and error. I suspect that companies like RCA, GE, and Western Electric that had large research laboratories approached the tube-building job more systematically than the smaller tube makers like Tung-Sol.

I was responsible for production of two small-lot military types, the 2C51 and the 5670, both double triodes. I developed for production the 6CG7 (a clone of an RCA-developed tube). Quality control in those days was not what it is today. I recall one incident when we were making 6CG7s and someone neglected to degrease the plates that we received from RCA. The entire batch of tubes proved to be defective!

The grids on the tubes that I dealt with were silver- or gold-plated. The RCA 6BK7A was designed originally with gold-plated grids. But after high-temperature processing, the gold migrated to the cathode and caused problems. Later I changed to silver plating for the grids and that seemed to work.

Tung-Sol had three *[tube]* manufacturing plants during that era: Bloomfield, NJ; Washington, NJ; and Weatherly, PA. Chatham Electronics, a northern NJ manufacturer of industrial tubes, was also owned by Tung-Sol. In 1958 Tung-Sol began to make transistors, but like many vacuum-tube companies, they did not master the transition to solid-state components. I am not sure what happened to Tung-Sol after I left. Perhaps some other readers can fill in the recent history.

EARLY GETTERS IN THE TUBE INDUSTRY

Abel Santoro, LU8DXI

The object of a "getter" is to obtain and maintain high vacuums in devices such as incandescent lamps and radio tubes, without requiring the use of extremely low-pressure pumps, while being adaptable to factory operation on rotary oil vacuum pumps.

In radio tubes it is desirable, in order obtain uniform results and to prevent arcing between the electrodes and the consequent destruction of the filament, to produce and maintain a high vacuum. Such gases as carbon dioxide and oxygen act to destroy the emissivity of the filament and have other detrimental effects. The gases usually present in the tube after it has been exhausted to a moderately high vacuum are water vapor and carbon dioxide given off from the glass and from the decomposition of the carbonate coating on the filament (in the case of oxide-coated cathodes), residual air, oil vapor from the pumps, and carbon monoxide and hydrogen given off by the plate of the tube. It is not practical to remove these various gases and vapors completely by means of pumps since such operation is very long and expensive and pumps suitable for this purpose are very costly.

It is the usual practice, therefore, in the manufacture of radio tubes, to exhaust the devices to a moderately high vacuum by means of rotary oil pumps and to clean up residual gases and vapors by means of getters.

THE PHOSPHORUS GETTER

A much used getter in early history of the incandescent-lamp and the vacuum-tube industries was phosphorus. It was historically the first getter to be employed commercially. The name Phosphorus means "bearer of light." It was discovered in Hamburg by the German alchemist Henning Brand in the year 1669. One of the most important advances in the production technique of incandescent lamps was the invention of a new and much more efficient method of producing a vacuum in the lamp bulb by means of phosphorus. The inventor of this process was an Italian engineer named Arturo Malignani, who had set up an electric lighting plant in his home town of Udine and was producing his own incandescent lamps.

Fig. 1. Arturo Malignani, 1965-1939

The use of phosphorus as a getter began with the incandescent lamp industry, because of its transparency to light when deposited in a thin film inside the bulb.

One early gettering process consisted of introducing into the bulb a small amount of one of the following substances: arsenic, sulphur, iodine or phosphorus. When the vapors of one of these elements were introduced in the lamp, the filament was lighted with a high current, and then the lamp was closed from the pump. A high vacuum was produced inside the lamp when a small amount of red phosphorus vapor was placed in the exhaust tube while the filament was heated above normal operating temperature.

The Malignani chemical-exhaust process was also improved between 1894 and 1912. In that process, as has been stated, vaporized phosphorus was driven into the bulb during the later stages of exhaust to clean up the residual gases. The process was physical rather than chemical, as the molecules of the gases were driven to the bulb and firmly held there unless the phosphorus was again vaporized.

The Malignani exhaust process represented a considerable step forward in the technique of lamp assembly, yet somewhat the same principle had been employed as early as 1882 in the Fitzgerald lamp. In that lamp a third terminal was connected to one of the two regular terminals by a short piece of iron

wire wrapped with magnesium ribbon. When the filament was heated during the exhaust process, the wire became hot and the magnesium combined with the residual oxygen. This was probably one of the first gettered commercial lamps. The getter might also reduce bulb discoloration.

The Malignani chemical-exhaust process was similarly adopted by many lamp producers throughout Europe. The phosphorus exhaust method was introduced to America in 1896.

When news of the discovery reached the General Electric Company, it immediately dispatched a representative to buy the American rights to the process. The General Electric lamp engineers improved the technique and were able to reduce exhaust time to less than a minute.

Around 1909 the technique was improved and simplified by John T. Marshall of GE. He coated the filament by dipping it into a mixture of phosphorus and water, and the phosphorus was vaporized after the exhaust by running a strong electric current through the lamp.

Since that time phosphorus has been supplanted by other getters. The introduction of the tungsten-filament lamp created an increased need for new getters, since the bulb blackening was greater with the tungsten than with the carbon and other lamps.

The first special getter for tungsten-filament lamps was the compound of phosphorus, nitrogen and hydrogen (phospham) employed in 1906 by the German "Z" company for decarbonizing metal filaments. It was soon discovered that phospham left in the bulb would combine with other residual and destructive substances to reduce bulb blackening. Around 1910 the Felten-Guillaume-Lahmeyer company developed a similar getter. A nitrogen compound free of hydrogen, such as phosphorus nitride, was used to decrease filament disintegration. The hydrogen was omitted because it tended to become ionized and short-circuit the lamp filament during the operation.

A new type of getter was invented by the Austrian chemist Franz Skaupy in 1911. He suggested placing halogen compounds of a metal in a hollow of the glass filament support, where they broke up as the lamp was heated in use. The liberated gas combined with the tungsten given off by the filament and produced a much higher deposit on the bulb and a smaller decrease in effective light output. Skaupy's potassium-thallic-chloride was so active that in smaller sized lamps it attacked the filament, consequently it was used only with bulbs over 100 watts.

Other chemical compounds were also used as getters. In 1912 Dr. Fink of General Electric adapted potassium iodide for use with lamps from 15 to 40 watts, and he simplified the method of mounting it on the glass support. In the same year Harry H. Needham, also of GE, adapted the double fluoride of sodium and aluminum known as cryolite for use as getters in lamps from 25 to 60 watts. The introduction of inert-gas fillings into lamp bulbs also had the important gettering effect of decreasing filament decomposition and bulb blackening.

The A. E. G. Company used low-pressure carbon monoxide in its carbon lamps in 1901. Attempts to employ gas fillings were renewed after the commercialization of the tungsten-filament lamp. Nitrogen filling was mentioned again in a 1908 patent by a French lamp manufacturer, and mercury vapor was used to exert pressure upon the carbon filament in a lamp developed in 1908 by the German, R. Hopfelt.

The suggestions before 1912 for filling lamps with gases were scattered and haphazard. While some of the inventors who tried inert gases had the right idea about their value, they did not study the problem systematically, and their achievements were not great. The development of the successful gas-filled tungsten lamp, with eventually superseded the vacuum lamp in most of the important sizes, was completed by Dr. Irving Langmuir of the GE Research Laboratory in 1912.

The process employed nowadays in lamp manufacture, is somewhat simpler than this. A fine suspension of red phosphorus in alcohol or amyl acetate, prepared by prolonged ball milling, is painted or sprayed on the filament and adjacent parts of lead-in wires, and, after the pinch has been sealed into the bulb, the lamp is pumped, baked and sealed off in usual way. Getters are used in almost all modern incandescent lamps.

As in the lamp industry, red phosphorus was employed in early radio-tube manufacture as a getter for the purpose of cleaning

up residual gases and vapors. The method employed consisted in painting the red phosphorus directly onto the plate or grid of the tube and vaporizing it by heating the anode by high-frequency induction currents. This getter type is adapted to the production of high vacuums in radio tubes employing an oxide-coated filament and other filament forms such as pure or thoriated tungsten.

But when red phosphorus was used in this manner, the behavior of the tubes was erratic and with non-uniform emissivity.

As the red phosphorus produced at that time was chiefly for the manufacture of matches, it was difficult to obtain it in a pure state. It contained over 10% of such impurities as silica, iron oxide and hydrocarbons, which were liberated when the phosphorus was vaporized in the tube, causing detrimental effects on the filament emission.

The red phosphorus obtained in a pure condition was, moreover, very unstable in the atmosphere, transforming rapidly into phosphorus pentoxide because of the oxygen in the air. The phosphorus pentoxide in turn absorbs moisture from the air, forming phosphoric acid.

Limiting the formation of phosphoric acid was a problem in commercial radio tube manufacture at that time, since the acid is formed before the phosphorus can be introduced into the tube. When the phosphoric acid is heated inside the tube to liberate the phosphorus, water vapor was also liberated, causing oxidation of the active cathode material and loss of emission.

The difficulties incident to the use of red phosphorus for clean-up purposes were overcome by employing it in such a way that the impurities therein were cleaned up before they had an opportunity to impair the cathode emission or using impurity-free phosphorus. It was discovered that the oxide film which is always present on the surface of cold electrodes may be decomposed by the action of yellow phosphorus vapor thereon and that, when this film is destroyed prior to the operation of the cathode, high emission is obtained for a long commercial life of the tube.

It was preferable to introduce the phosphorus into the envelope in the form of a compound stable in the atmosphere which is readily reducible within the envelope to liberate pure yellow phosphorus. For this purpose commercial red phosphorus was introduced into the device, intimately mixed with a reducing agent such as aluminum, and then the mixture was vaporized by heat, the phosphorus being liberated and the impurities contained therein cleaned up by the reducing agent. The phosphorus vaporized entirely at 700°C, the red phosphorus decomposing into yellow phosphorus. A compound very suitable to produce pure yellow phosphorus within the envelope was calcium metaphosphate mixed with silica and a reducing agent such as powdered aluminum. Silica was added to the getter material to prevent the formation of orthophosphate and the liberation of free sodium or calcium in the envelope which would affect the grid bias by deposition on it.

The materials constituting the getter are finely divided and mixed with a suitable binder such as a solution of nitrocellulose in amyl acetate, which is prepared by prolonged ball milling, this solution being applied to the plate of the tube with a brush or spraying.

Fig. 2. "R" valve

The quantity of the getter applied to the plate of the tube must be restricted to as small an amount as is compatible with thorough reduction of the oxide film on the plate. If too much phosphorus were employed, the tube would be gassy, since yellow phosphorus has an appreciable vapor pressure at the operating temperature of the tube. With too much vapor present inside the tube, positive

bombardment of the filament would occur, resulting in temporary loss of emission, particularly with thoriated-tungsten filaments. In such a case the electron emission can be restored by seasoning the tube for a sufficient length of time. This is due to the conversion of yellow phosphorus to red phosphorus when the vapor of the same is ionized, and diffusion of a new supply of thorium to the surface of the filament.

The glass bulb of the tube with phosphorus getter, acquired a typical obscuring deposit which varied from reddish brown to a yellow color, depending upon the amount of excess phosphorus.

Figure 2 shows an "R" valve with a phosphorus getter showing the characteristic bright yellow-orange color in the glass bulb.

THE LIME GETTER

Lime is the name given to calcium oxide (CaO). It does not occur naturally since it reacts readily with water to form hydrated lime and carbon dioxide (CO_2), to form limestone. Calcium oxide is also known as burnt lime, calx and cal.

In its pure form, lime occurs as white crystals, white or gray lumps, or granular powder. It has a very high melting point of 2,572 °C and a boiling point of 2,850 °C.

The use of calcium in the production of high vacuum was first proposed in 1907 by the English chemist Frederick Soddy (Figure 3), to clean up the gases in vacuum chambers. It was used to improve the vacuum of hard valves in 1916.

Fig. 3. Frederick Soddy

The lime getter was further developed in early 1923 by Lee Sutherlin, a Westinghouse engineer who started to work for this company in 1920. Sutherlin was involved in the design of the WR21 Aeriotron tube. The early Aeriotron had no getter, but when Westinghouse made these tubes for RCA they used Sutherlin's lime getter, whereby these getters are also called Sutherlin getters.

The calcium hydroxide was applied in the form of a water suspension produced by slaking a quantity of calcium oxide or lime with a small amount of distilled water in a mortar, breaking up the calcium oxide with a pestle, adding additional water or alcohol and grinding to a paste-like consistency. The calcium hydroxide so formed was painted onto the stem of the tube prior to the sealing-in operation. The mixture had to be used fairly soon after it was made, within 12 to 24 hours, because it absorbs carbon dioxide from the atmosphere. For this reason the assembled tube with the getter applied to the stem, had to be exhausted as soon as possible.

The lime getter on the stem would absorb a large part of carbon dioxide and water vapor given off by the filament and glass parts of the tube, the carbon dioxide combining with the lime to form calcium carbonate, and the water vapor to form calcium hydroxide.

The lime however, does not appear to have been effective for cleaning up hydrogen, oxygen, carbon monoxide or oil vapor. For this reason the vacuum pumps of the tube factory had to evacuate the tubes to as high a vacuum as commercially possible.

In the Westinghouse research laboratories tests were made on multiple WD-11 and WD-12 tubes, with and without getters, and averaged. The numbers of tests, and the values of plate resistance and emission were the following:

Tube	Tests	Emission	Plate Res.
WD-11	14 w/o lime	20.00	15954
WD-11	15 w/ lime	36.00	13247
WD-12	9 w/o lime	5.44	17917
WD-12	8 w/ lime	31.20	15756

In these tests all conditions were made as nearly identical as possible except for the addition or omission of the getter. In these experiments it was found that the use of lime decreased the plate resistance of the tube and considerably increased its life.

As an example, Figure 4 shows a nongettered Radiotron WD-11. In September 1924

the bulb size of the WD-11 was reduced to T8 and the base was changed to bakelite. In February 1925, the WD-11 was made in a tipless bulb with a magnesium getter, but in Figure 5 one can see a WD-11 with a T-8 tipless bulb, still with a lime getter.

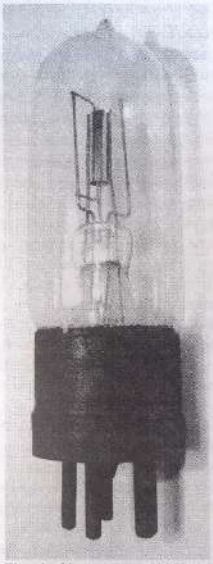

Fig. 4. Nongettered WD-11

THE MAGNESIUM GETTER

Magnesium first began to be used on a large scale as a getter in the commercial production of radio receiving tubes in the early nineteen-twenties, beginning in 1923 in European tubes.

While having a moderately high gettering capacity, being fairly active chemically, it was not so active as to be hard to use in production.

Early practice was to spot-weld a snippet of magnesium ribbon to the anode. This was then dispersed or distilled to form a mirror-like film on the glass, at same time as the anode was given its final degassing by electron bombardment or eddy-current heating. Unfortunately this procedure made inevitable a certain amount of contamination of the dispersed getter by gas still coming off from the anode. So, in 1927 the operations of electrode degassing and gettering were made independent of one another.

The electrodes were degassed first, and only after the bulk of the evolved gas had been pumped away, was the getter dispersed by eddy currents which heated a small nickel disk to which the piece of magnesium was attached, the disk being mounted on a separate wire in a plane at right angles to the plane of the anode.

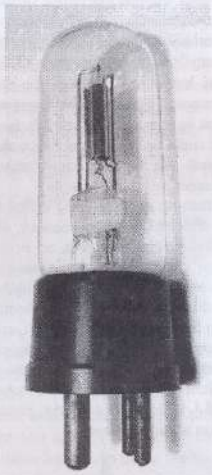

Fig. 5. Tipless WD-11 with lime getter

Magnesium, in common with other metals, contains gas of its own, the gas in the case being mainly hydrogen. Much, though not all of it, is associated with surface corrosion. Therefore only clean magnesium ribbon could be used and the ribbon should preferably not be too thin. The piece to be used for gettering could be either clipped in place on the getter disc or spot-welded to it. In the latter case it was well to remove any oxide formed during the welding operation. These precautions having been taken, any remaining gas evolved by the getter and by the disk on which it was mounted during dispersal could be rendered practically harmless by carrying out the gettering operation before sealing off from the pump, rather than after. Most of the gas was then pumped away, and did not have to be dealt with by the getter.

There is a widespread impression that the

main fixation of gas by the magnesium getter occurs during the dispersal. This was by no means the case. Owing to the gas given off by the getter itself, the pressure tends to increase, not decrease, during the dispersal. In the mass production of radio valves at the moment of the seal-off it was commonly as high as 10^{-2} mm Hg and seldom much lower than 10^{-3} mm Hg. The real work of the getter is done after the glass envelope of the valve has been sealed off.

Magnesium cleans oxygen to a pressure sufficiently low for the operation of thoriated filaments but is not as active for hydrogen and nitrogen. However, its freedom from oxidation in air and the relative ease with which it could be fastened to the anode led to its general use in tube manufacture until displacement by other materials.

The clean-up of oxygen by diffused magnesium appeared to be permanent, since no gas evolution occurred even on heating the deposit to 265°C. No clean-up was observed in the case of hydrogen and nitrogen, however, a deposited layer of magnesium would clean-up the gas in the presence of an electrical discharge. According to experimental observations it is probable that the use of magnesium as getter in radio tubes was successful largely because the presence of ionization in such devices.

Fig. 6. Magnesium-gettered D. E. R.

For use in commercial production of tubes, the getter should, in general, be in a form which can be volatilized by high-frequency heating. The magnesium had to be chemically inert during tube assembly, and after the mechanical exhaustion it should become highly active chemically. The transformation from the inactive to the active state was carried out by the application of heat, producing it a change in the chemical composition as in the phosphorus or an evaporation of active metals protected by oxide films as the case of magnesium.

Magnesium may be formed from its carbonate. In an experiment carried out by A. L. Reimann, he investigated the clean-up of gases by evaporation of magnesium. The most significant conclusion was that a clean magnesium surface or mirror takes up large amounts of hydrogen. The process of clean-up is one of "contact gettering" and the hydrogen diffuses inward rapidly. The hydrogen is also cleaned-up during the slow evaporation of the magnesium into the vacuum tube. The hydrogen captured by contact gettering could be reliberated from the magnesium mirror if it were bombarded with electrons from the internal electrode structure of the tube. Avoiding this effect required special care in the internal design of the tube.

Experiments made by E. Lederer in the Westinghouse research laboratories in the manufacture of the UV-199 low-power tube found that 5 mg. of magnesium mixed with 2.5 mg. of copper phosphide were sufficient to absorb the residual gases in the tubes.

Figure 6 shows, as an example, a Marconi-Osram Valve D. E. R. (Dull Emitter "R") magnesium-gettered tube. It shows the silvery mirror color inside the bulb.

The use of phosphorus, lime or magnesium as getters in the tube industry was replaced, beginning in the late '20s, by such other getter types as barium compounds.

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LIFE-BOOST CATHODE NOW STANDARD EQUIPMENT ON 90 SYLVANIA TUBE TYPES

Sylvania News, Fall 1962

The practical importance of a significant tube improvement depends upon how swiftly that improvement is incorporated into tube types on the market. An improvement in the manufacture or design is highly desirable, but until it gets out of the laboratory and into the tubes on your shelf it's of little or no real value to you or your customers.

That's why Sylvania engineers and manufacturing personnel have moved to incorporate Life-Boost Cathode into as many marketed tube types as rapidly as possible. The result is that Life-Boost Cathode is now standard equipment on over 90 Sylvania receiving tube types. That means that when you install any of the Sylvania types listed [below], that tube is going to perform better than any of its predecessors, better than any competitive brand of the same tube type. Remember, Life-Boost Cathode is an exclusive Sylvania feature. Like Sarong and Bikini Cathodes (prior Sylvania tube improvements and still exclusive with Sylvania tubes), Life-Boost Cathode and the superior performance it creates is only available with Sylvania Receiving Tubes.

TYPES USING LIFE BOOST CATHODES

2/3AF4B	6AN5	6BL8	6/12DQ6B	10JY8	25DN6	6146, A
2/3/6DZ4	6AS5	6BQ5	6/12DT5	12DB5	25EH5	6159A
3/4/6CB6A	6AU8, A	6/12/25BQ6G	6/8ET7	12ED5	25F5	6186
3/6DE6	6/12AV5GA	TA, B	6GK6	12BV7	32ET5A	6883A
4/6/12BZ6	6BC5	6CA5	6GR7/SR-	12BX7	35/50C5	7056
4/6DE6	6BF5	6CB6, A	3213 *[sic]*	12BY7	50B5	7060
5/6EW6	6/12/25BK5	6/25CD6	6/8GN8	12CA5	5687WA	
5/6GM6	6BH8	6CF6	6J4WA	12DB5	GB-6080	
6AF4A, B	6/12/25BK5	6CU5	6K6	12ED5	6080WA, WB	
6AH6, WA	6BL7GTA	6DQ5	6V6	12BV7	6082	

Look over the list of Sylvania tube types currently incorporating Life-Boost Cathode. Keep the list handy and next time your tube order includes any of these types be sure you specify Sylvania. Only Sylvania tubes have Life-Boost Cathode.

LIFE-BOOST CATHODE: WHAT IT IS, HOW IT IMPROVES PERFORMANCE

Life-Boost cathode results from an entirely new method of forming the basic cathode material. Conventionally, cathodes have been formed from melted metals. Life-Boost cathodes are produced from powdered metals, compacted and rolled into a thin-gauge cathode. Pure nickel powder plus carefully controlled powdered reducing agents are thoroughly blended and immediately rolled. Because no critical temperatures are involved, no impurities are introduced from crucibles and containers, forging hammers or hot-rolling equipment. And, the powder process permits previously impossible or hard-to-attain combinations of wanted properties, such as electrical passivity and mechanical strength at high temperature.

The Life-Boost cathode alloy is much purer and more uniform than conventional cathodes. Alloys may be better controlled to promote uniformity and inhibit the formation of leakage paths, thereby extending tube life. It also means better stabilized electron emission and regulated barium release throughout life - tube performance stays within specifications.

The end result is improved tube performance, extended tube life. And fewer callbacks for dealers. (Actual tests have already proved the superiority of tubes with Life-Boost cathodes. See the Summer Issue of *Sylvania News* for example of test results).