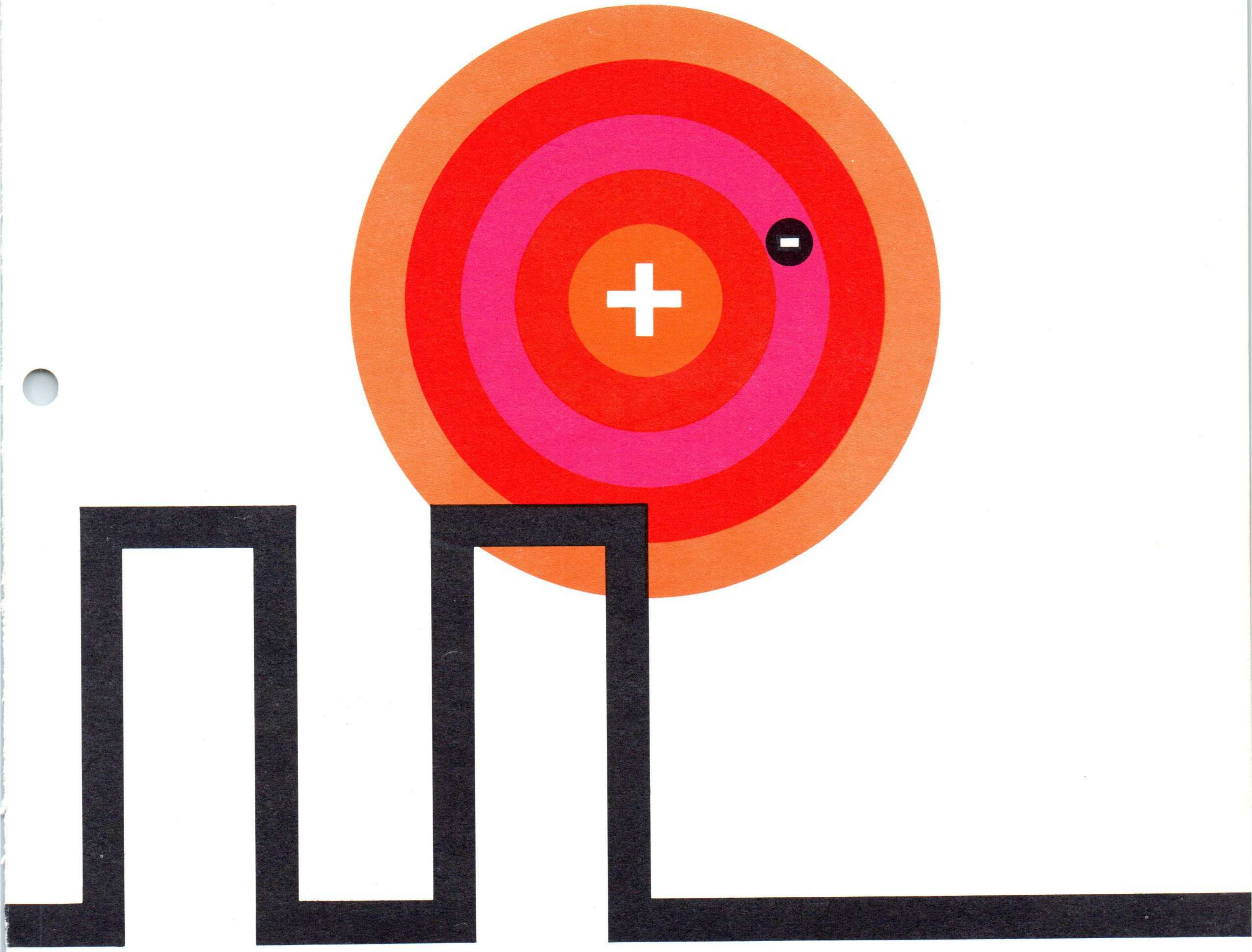
HYDROGEN FILLED TUBES

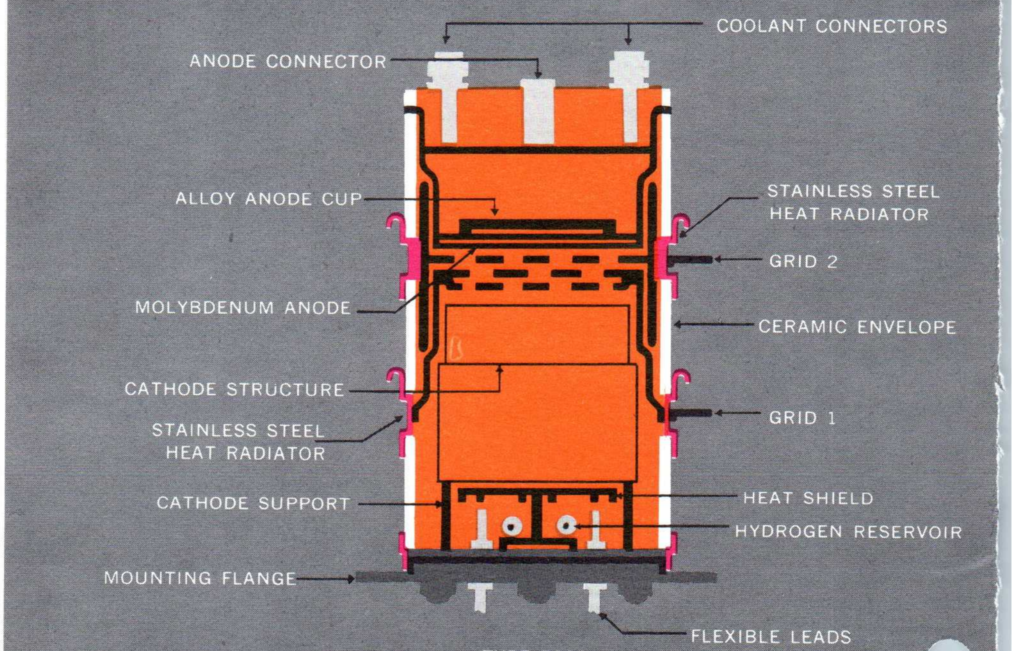


TUNG-SOL ELECTRIC INC.

HYDROGEN FILLED TUBES

The use of hydrogen has made possible a class of high power switching tubes with certain unique properties. They can operate over a wide range of plate voltages and are capable of passing peak currents in excess of 2000 amperes. They are not susceptible to ambient temperature problems, and because of a shorter ionization time, they switch faster. Further, in hydrogen filled tubes the oxide cathode does not suffer from the bombardment of the high energy but light weight hydrogen ions. Thus, the tube has longer life. Tung-Sol has developed a line of hydrogen tubes incorporating the best of proven basic designs with tested features. For example, in all medium and high power tubes the naturally long life of the tube is increased by incorporating a hydrogen reservoir capable of storing many times the normal tube volume of the gas. A characteristic instance of advanced thyratron design is shown below in the structural arrangement of the Tung-Sol Type 7890—a ceramic hydrogen thyratron.

TYPE 7390



TYPE 7890

CERAMIC

The Tung-Sol Ceramic Type Hydrogen Thyratrons and Rectifiers have been developed to meet the increased demands for improved characteristics in power handling devices. The use of ceramic envelopes provides mechanical characteristics which are highly resistant to shock and vibration. In addition, they exhibit superior thermal properties, and can be made smaller. More significant, however, the use of a ceramic envelope permits improved electrical design. The close control over spacing which is made possible by this type of construction allows more precise positioning of elements and thereby more predictable operating characteristics. It also insures a high order of product uniformity.

The Type 7890 shown below is typical of the design of Tung-Sol hydrogen thyratrons. It is a four element, zero bias unit designed for high power switching and is capable of handling 48 megawatts peak power. The employment of a gradient grid makes it possible to obtain a more effective d-c holdoff at the maximum forward voltage rating than is possible in a conventional thyratron. A titanium hydride reservoir permits long life and promotes stable operation by maintaining a constant hydrogen density.

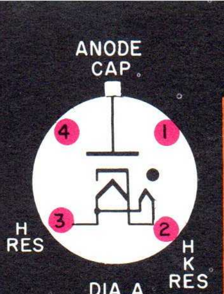
THYRATRONS

	THYRATRON RATINGS								HEATER			PHYSICAL	
TYPE	po Mw	Pb x10^9	epy kv	Ebb kVdc min.	ib a	Ip Aac	Ib Adc	epx kv	If Aac max.	ER Vac	IR Aac max.	ht. o.a. in max.	dia. in nom.
8191	.180	1.20	6.0	0.3	60	1.8	.050	6.0	3.5	I.C.	—	2.40	1.13
7621	.400	2.70	8.0	0.3	100	2.0	.100	8.0	3.5	I.C.	—	2.40	1.15
8192	.450	3.00	9.0	0.3	100	3.3	.100	9.0	5.0	I.C.	—	3.13	1.60
8036	6.25	6.25	25.0	3.0	500	15.	.500	25.0	12.0	2.5-5.5	2.5	6.00	2.60
7322	12.5	20.0	25.0	1.5	1000	36.	2.0	25.0	22.0	5.8-6.8	6.8	6.20	3.06
7390	33.	30.0	33.0	3.5	2000	72.	4.0	33.0	35.0	3.5-5.5	10.0	12.5	5.25
7890	48.	55.0	40.0	3.5	2400	75.	4.0	40.0	40.0	2.5-5.5	12.0	14.4	5.25

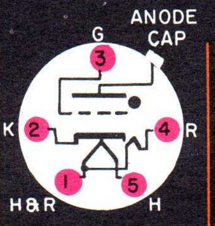
DIODES

	CLIPPER DIODE RATINGS					RECTIFIER RATINGS			HEATER				PHYSICAL	
TYPE	epx kv	ib a	Ib mAdc	ip Aac	epk v	epx kv	ib a	Ib Adc	Ef Vac	If Aac max.	ER Vac	IR Aac max.	ht. o.a. in.	dia. in max.
8373	12.0	60	50	1.8	100	12.0	1.0	0.25	6.3	3.20	I.C.	—	2.40	1.13
8374	15.0	100	100	3.3	100	15.0	2.0	0.50	6.3	4.75	I.C.	—	3.13	1.60
8375	25.0	200	300	7.7	125	20.0	4.0	1.0	5.0	12.0	5.0	3.0	6.00	2.60
8376	33.0	750	750	25.	125	25.0	8.0	2.0	5.0	16.0	5.0	4.0	7.80	3.06
8377*	33.0	2000	5000	60.	150	26.0	28.0	7.0	5.0	25.0	5.0	5.0	9.50	4.56

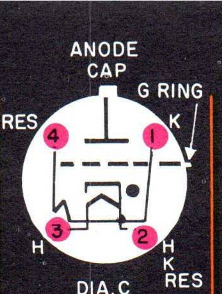
*TENTATIVE RATINGS   ALL TUBES LISTED ABOVE HAVE FLEXIBLE LEADS   ALL THYRATRONS HAVE 6.3 VOLT HEATERS



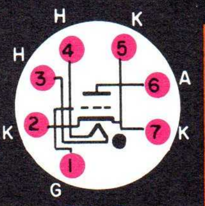
DIA. A



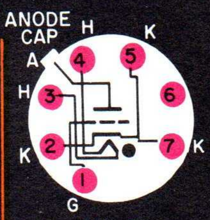
DIA. B



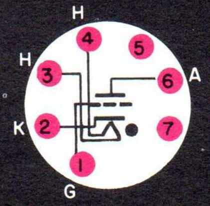
DIA. C



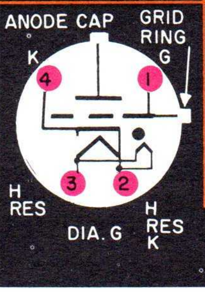
DIA. D



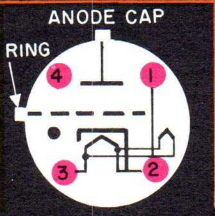
DIA. E



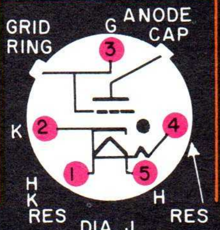
DIA. F



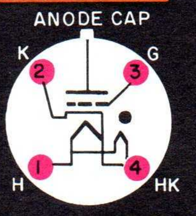
DIA. G



DIA. H



DIA. J



DIA. K

GLASS

DISC SEAL DIODES

RATINGS	CLIPPER DIODE					RECTIFIER			HEATER				PHYSICAL		
	epx kv	ib a	Ib mAdc	Ip Aac	epk v	epx kv	ib a	Ib Adc	Ef Vac	If Aac max.	ER Vac	IR Aac max.	ht. o.a. in.	dia. in max.	Pin Conn
7789	13.0	150	200	5.5	100	15.0	1.6	0.4	5.0	9.3	I.C.	—	7.25	2.16	A
7790	25.0	200	300	7.7	100	20.0	4.0	1.0	5.0	12.5	I.C.	—	7.75	2.60	A
7791	33.0	750	500	20.0	125	25.0	8.0	2.0	5.0	17.0	I.C.	—	7.76	3.156	*
7792	33.0	750	500	20.0	125	25.0	8.0	2.0	11.5	10.5	I.C.	—	9.75	2.97	A
7793	33.0	1000	1.0	30.0	150	25.0	16.0	4.0	5.0	25.0	5.0	5.0	6.63	4.01	*

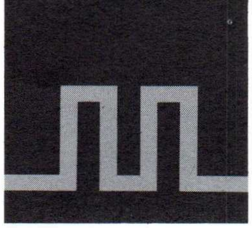
CLIPPER AND CROWBAR THYRATRONS

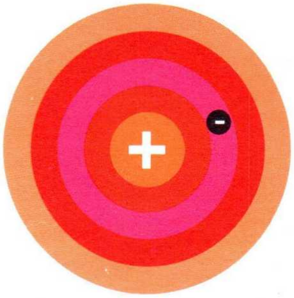
RATINGS	THYRATRON							HEATER				PHYSICAL		
	Ep KV	epx KV	ib a. fault	ib a.	Ip A.a.c.	Ib Adc	ib 50 MS a	Eh Vac	If Aac max.	ER Vac	IR Aac max.	ht.o.a. in max.	dia. in nom.	Pin. Dia.
7568	25.0	15.0	—	800	—	0.5	50	6.3	22.0	2.5-5.5	6.5	12.50	3.31	B
7590	25.0	15.0	—	1000	—	0.5	50	6.3	22.0	2.5-5.5	6.5	12.50	3.31	B
7454	—	25.0	1200	325	6.3	—	—	5.0	16.0	I.C.	—	7.25	2.56	H
8080	—	25.0	1200	325	6.5	—	—	5.0	10.5	3.5-5.0	5.0	7.25	2.56	C
7559	25.0	15.0	—	1500	—	1.0	100	6.3	33.0	2.5-5.5	6.5	16.25	5.13	*
7605	30.0	15.0	—	3000	—	2.5	180	6.3	40.0	3.5-6.0	12.0	20.87	7.13	*
7455	—	33.0	2900	800	16.0	—	—	5.0	25.0	I.C.	—	8.70	3.70	*

THYRATRONS

RATINGS	THYRATRON							NETWORK	HEATER			PHYSICAL		
	po Mw	Pb $x10^9$	epy kv	Ebb kVdc min.	ib a	Ip Aac	Ib Adc	Zn Ohms nom.	If Aac max.	ER Vac	IR Aac max.	ht.o.a. in max.	dia. in max.	Pin. Conn
1258	.008	0.10	1.0	.30	20.0	1.0	.050	25	2.0	None	—	2.18	.87	D
7190	.010	0.10	1.2	.30	20.0	1.0	.050	30	2.0	None	—	2.13	.85	D
7191	.010	0.10	1.2	.30	20.0	1.0	.050	30	2.0	None	—	2.42	.85	E
7192	.010	0.10	1.2	.30	20.0	1.0	.050	30	2.0	None	—	2.75	.85	F*
7240	.010	0.10	1.2	.30	20.0	1.0	.050	30	0.46†	None	—	2.13	.85	D
8097	.010	0.10	1.2	.30	20.0	1.0	.050	30	0.46†	None	—	2.42	.85	E
7191A	.020	0.22	2.2	.30	20.0	1.0	.050	55	2.0	None	—	2.48	.85	E
E38	.220	1.25	5.0	.30	90.0	3.0	.100	27	6.7	I.C.	—	4.75	1.70	K
5957/E37B	.330	2.5	8.0	1.5	83.0	2.9	.100	50	6.7	I.C.	—	4.37	1.56	K
6587	2.0	3.9	16.0	3.5	325.	6.3	.225	—	11.6	I.C.	—	7.25	2.56	G††
7872	3.20	5.0	18.0	3.0	365.	7.0	.250	—	9.0	3.0-6.8	4.0	6.00	2.56	J
8253	3.50	5.0	20.0	3.5	365.	7.0	.250	—	12.0	I.C.	—	6.00	2.56	G
5949A/1907A	6.00	6.25	25.0	5.0	500.	15.8	.500	25	22.0	3.0-5.5	5.0	12.50	3.31	B
5948A/1754A	12.00	9.0	25.0	5.0	1000.	31.8	1.0	12.5	33.0	2.5-5.5	6.0	16.25	5.12	*
1257	33.00	20.0	33.0	3.5	2000.	60.0	2.6	8.3	30.0	3.5-6.0	8.0	20.87	7.12	*

†26 VOLT HEATER. ALL OTHERS HAVE 6.3 VOLT HEATERS ††NO GRID RING *FLEXIBLE LEADS





APPLICATIONS

The increased range and diversification of radar and radio transmission has led to a need for a variety of types of hydrogen tubes. The present Tung-Sol line has been designed to cover the complete spectrum of applications from miniature air-borne and missile requirements to space radar. Presently, the bulk of hydrogen tube applications falls in the following classes.

POWER SUPPLIES. Hydrogen diodes provide the most efficient means for high voltage rectification.

PULSE MODULATION. The microwave output tube, typically a magnetron, klystron or amplitron requires modulation by rectangular pulses which range from 0.1 microseconds in width, and with pulse spacing to 5 μsecs. In the line type modulator (FIG. 1) the pulses are produced by storing energy in a capacitor pulse forming network and then discharging through the thyratron. Peak power beyond 50 megawatts can be handled in this fashion with a minimum of modulator stages and with high efficiency.

CLIPPER CIRCUIT. Immediately after the main discharge pulse in the line type modulator, a negative voltage from the magnetron transformer finds its way to the capacitor network. A build-up of voltage over successive cycles can endanger the components and change the character of the discharge pulse. To prevent this a clipper circuit (FIG. 2) discharges this inverse voltage rapidly through a thyratron.

CROWBAR CIRCUIT. (FIG. 3) To protect a high power R.F. transmitting tube from the effect of arcing. Whenever an arc occurs in the power tube the rising current triggers the thyratron. This short circuits the power supply and diverts energy from the power tube until the time delay circuit breaker opens.

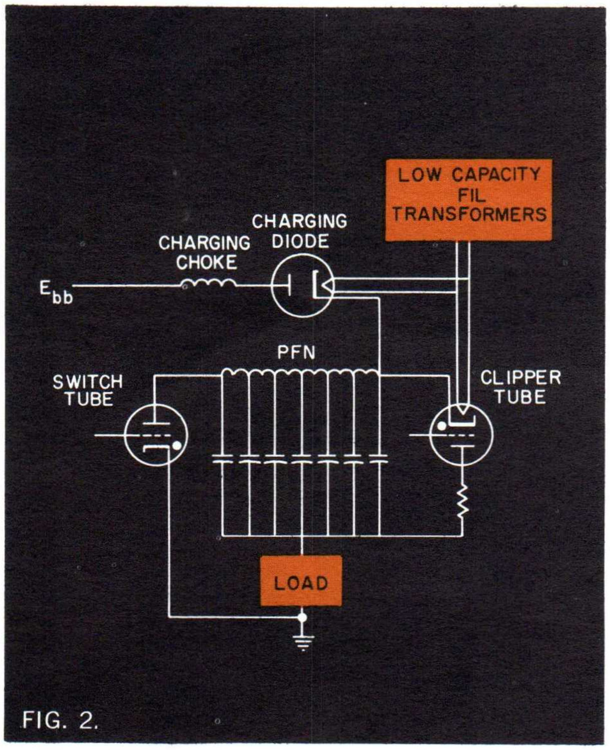


FIG. 2.

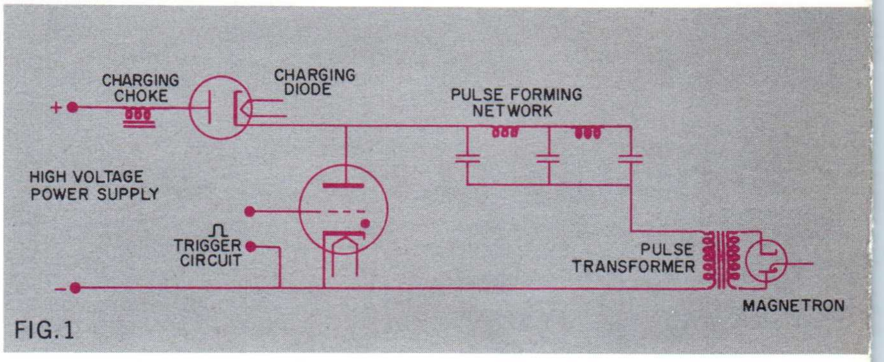


FIG. 1

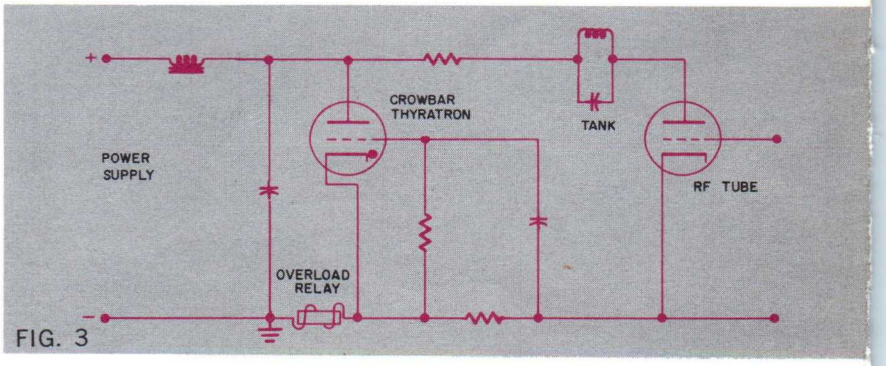
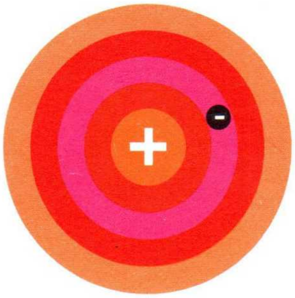


FIG. 3



The application as well as the design of hydrogen thyratrons and rectifiers is a dynamic thing. Increased requirements brought about by the greater range and higher definition of radar equipment have forced the development of new types of hydrogen tubes with greater power and more compact design. Moreover, realization of the capabilities of these devices has extended the area of use. High power, high frequency induction heating techniques are now using hydrogen thyratron tubes with real advantage. Hydrogen thyratrons are also being used to trigger light sources in laser applications.

Tung-Sol has been in the middle of this development from the beginning. It is aware of the capability and potential of hydrogen tubes and maintains constant research into the use and improvement of this class of component.

An experienced application staff is available at all times to quote or advise on standard or developmental hydrogen tubes.

For further information about hydrogen tubes or applications contact Tung-Sol Electric, Inc., Newark, New Jersey.

TUNG-SOL ELECTRIC INC. NEWARK 4, N.J.

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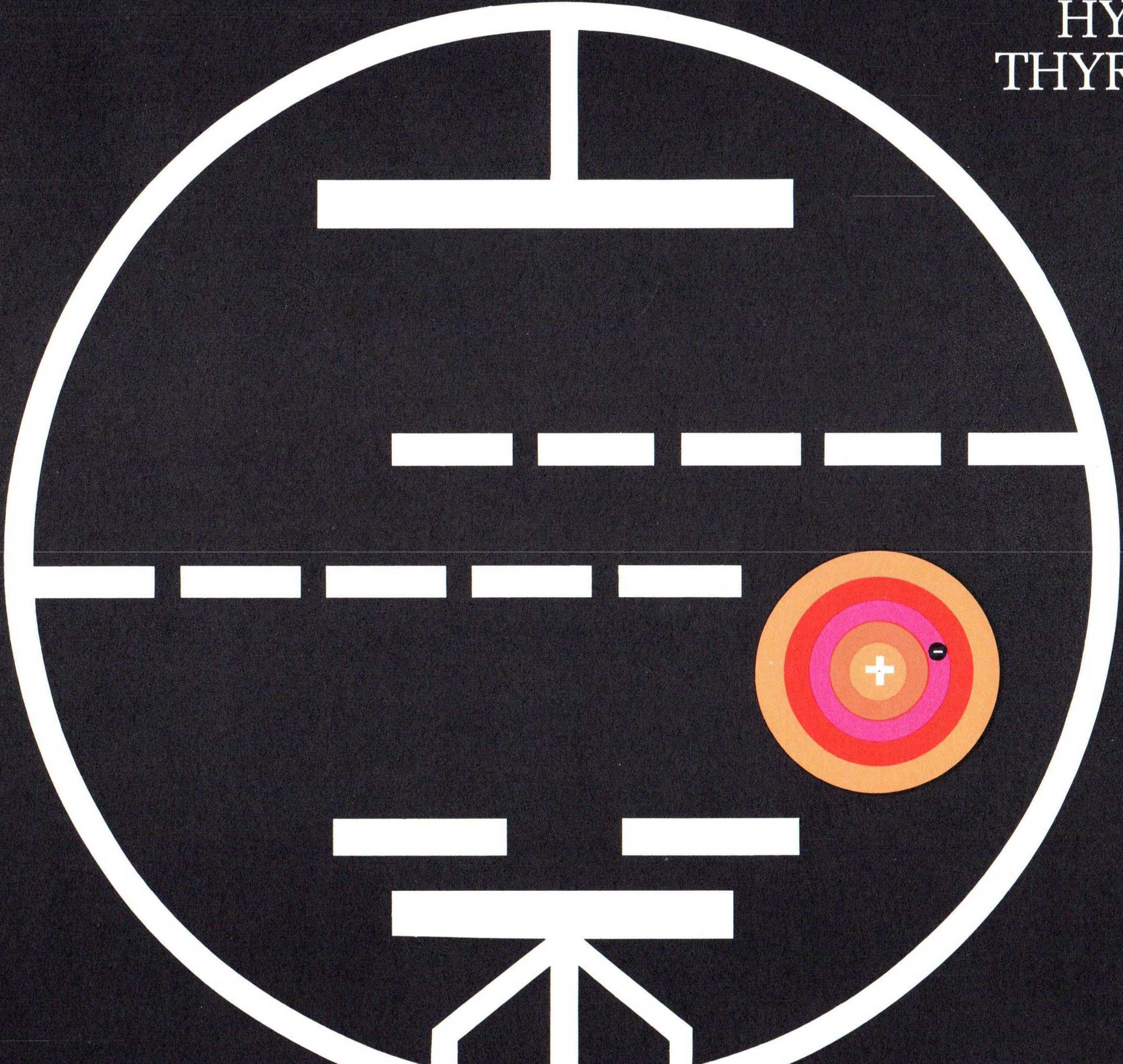
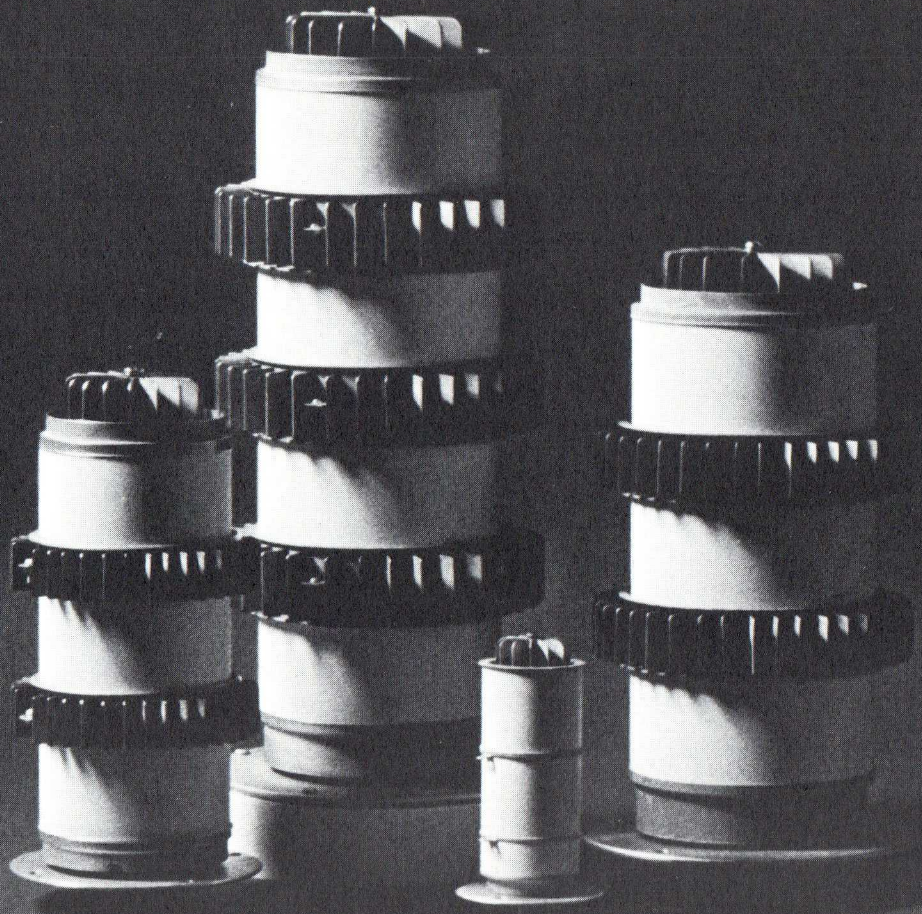
ULTRASTABLE HYDROGEN THYRATRONS



TUNG-SOL DIVISION/WAGNER ELECTRIC CORPORATION



THE ULTRASTABLE HYDROGEN THYRATRON

This booklet introduces a new type of ceramic hydrogen thyratron developed by the Tung-Sol Division of Wagner Electric to meet the special requirements of systems which use the technique of applying periodic accelerating forces to achieve extremely high energies. Such systems, because of their power capabilities and degree of control, are preferred in sophisticated radar applications, ranging from space communications to phased array acquisition radar systems and in linear accelerators of both research and industrial types.

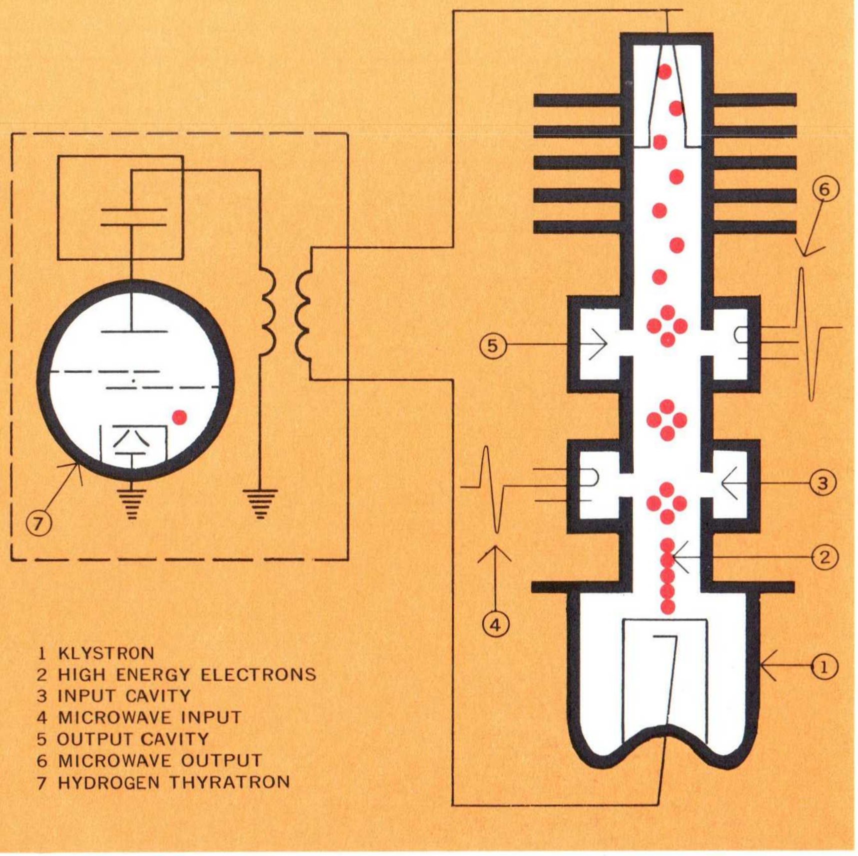
The basic element in these systems is the klystron, magnetron, amplitron or other microwave power tube used in combination with a ceramic hydrogen thyratron. These combinations are arranged in stages so that the output of each stage is amplified by the succeeding stage. This technique, while it can produce extremely high energies, imposes a severe requirement of timing precision on the thyratron. In general, the ceramic hydrogen thyratron is extremely well adapted to this application. It is small, has high power capabilities, is resistant to shock and vibration and can be manufactured with a high degree of uniformity. However, the order of precision required by the system exceeds the inherent capability of the conventional thyratron. Presently, by the use of compensating techniques, this precision can be achieved, but only at the cost of extra power, additional circuitry and reduction in system versatility.

The new Tung-Sol units, through advanced design and strict production controls, have switching characteristics, operating life and unit-to-unit uniformity unachieved by conventional thyratrons. They will minimize the discrepancy between requirement and performance, and materially reduce the cost of power, circuitry, space and maintenance in ultra-high energy systems.

CONTENTS

THE THYRATRON/KLYSTRON COMBINATION

FIG. 1 THYRATRON/KLYSTRON



A single stage in those systems involving periodic acceleration is composed of a microwave power tube and its driving mechanism—a line type modulator, whose principle active component is the ceramic hydrogen thyratron. The operation is illustrated in the drawing.

Thyratron. A heavy charge is built up and stored in the Pulse Forming Network. The thyratron, which is between the PFN and ground, acts as an open switch preventing the flow of electrons. When a positive pulse is applied to the grid, the following things happen: (a) The cathode grid space becomes ionized, (b) some of the ions in this region find their way to the anode, and a breakdown occurs. (c) The entire volume then becomes ionized and the thyratron now acts as a closed switch allowing energy in the PFN to discharge through the thyratron.

Klystron. When this energy is discharged, it creates a massive potential difference (200Kv) between the electrodes of the klystron. This imparts a high energy to the stream of electrons emitted from the cathode gun. At the same time, radiation of a specific microwave frequency is fed into the precisely tuned buncher cavity of the klystron producing an alternating magnetic field in the area of the cavity.

As the electrons from the cathode pass the buncher cavity, they encounter this periodically changing field which accelerates some of the electrons and slows others depending on whether the field is negative or positive when they reach it. As a result, the high energy electrons, after they pass the buncher cavity, are traveling in clusters spaced according to the frequency of the field. As these clusters pass the second tuned cavity (the catcher cavity) they produce an alternating field in the cavity which has the same frequency as that at the buncher cavity. However, due to the concentration of high energy electrons in the clusters, it is considerably more intense and the radiation at the output has a greater amplitude than at the input. This is a single stage station and is basic to the system. In multi-stage stations the output of the klystron is fed into the input of an identical thyratron-klystron combination stage for further amplification.

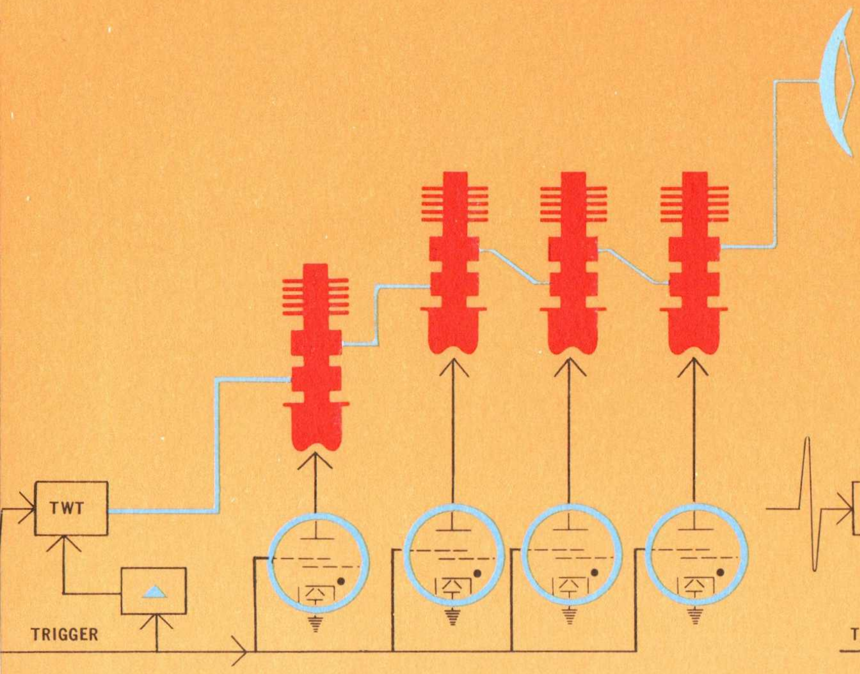


FIG. 2 HIGH POWERED RADAR

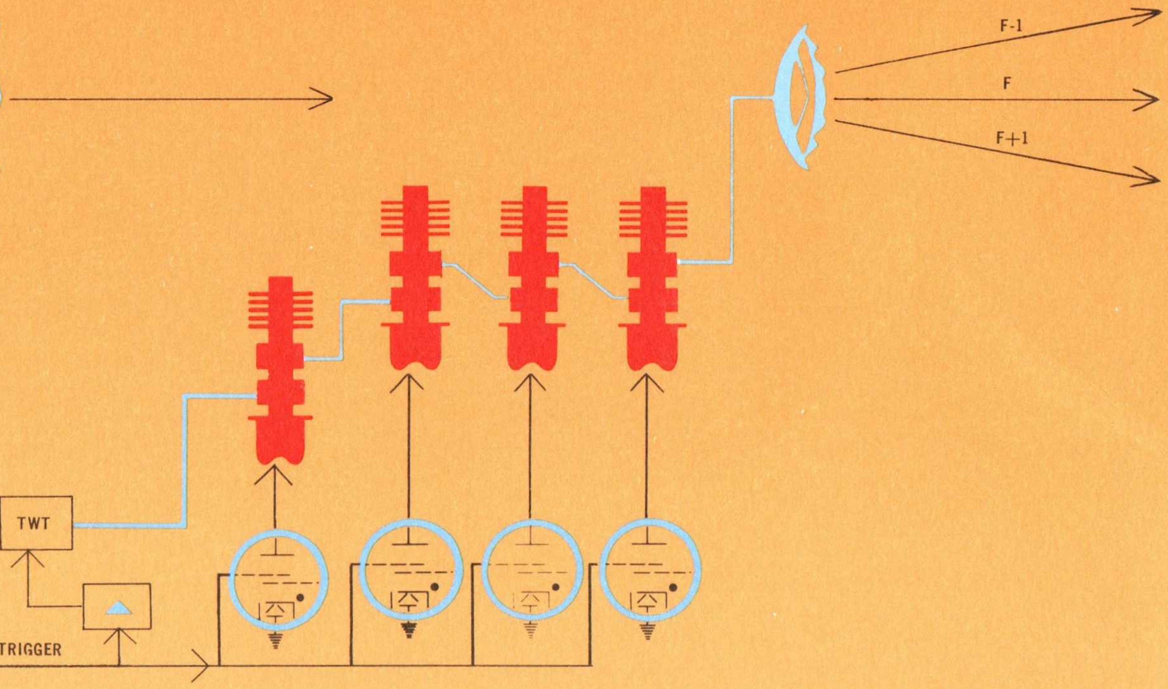


FIG. 3 ELECTRONICALLY STEERED ANTENNA

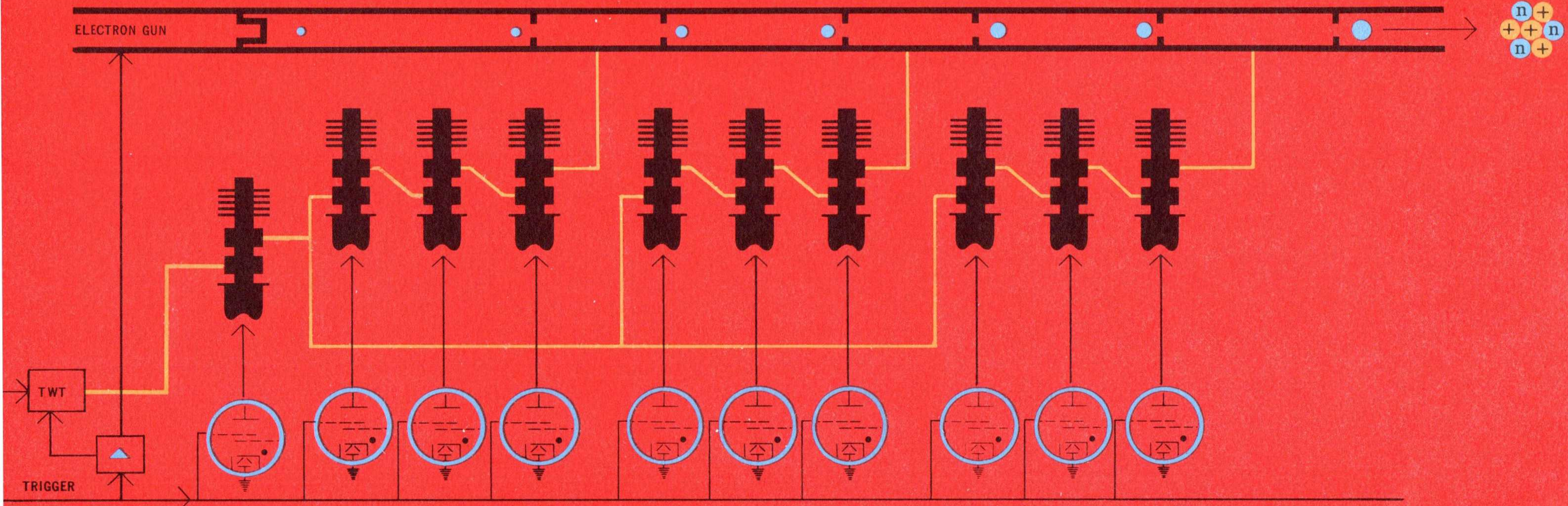


FIG. 4 LINEAR ACCELERATOR

HIGH ENERGY SYSTEMS

Extremely high energies can be developed by combining amplifying stages into groups called Stations. There are Single-station and Multi-station systems, and the Thyratron/Power Tube combination is fundamental to both. Two main areas of application are High Powered Radar and Linear Accelerators.

Radar. Figure 2 shows a single station, high powered, radar system. The system consists of a microwave generator, TWT and a series of amplifying stages. It operates as follows: A trigger pulse is applied simultaneously to the grids of all the thyratrons. This results in the emission of the high energy electron streams in all the klystrons (or whatever microwave tube is used). The same pulse, after a delay, triggers the TWT which sends a burst of microwave energy into the system. This signal is fed into the first stage and amplified. The amplified signal is then fed to the succeeding stage which produces further amplification. At the final stage, a burst of energy with the original frequency, but with extremely high amplitude, is delivered to the antenna.

The Delay. The delay between triggering the thyratron and the TWT is to assure that the thyratrons are fully turned on so that the potential difference between the klystron electrodes is at a maximum steady value before the microwave pulses arrive at the klystron. In this way, no distorted pulses enter the system—an important requirement in all radar systems but particularly critical in electronically steered antennas (fig 3) where frequency determines the direction.

Linear Accelerators. In nuclear applications, the linear accelerator is finding favor because of its simplicity and greater focusing control. The system (fig 4) uses an electron as the projectile. Its object is to direct the electron at the nucleus of the target atom with sufficient energy to overcome the forces which hold it together. The accelerator can be considered as a long wave guide consisting of a series of resonant cavities. Microwave energy applied to these cavities creates an alternating magnetic field in each of them, and they become accelerating spaces. At one end of the tube electrons are emitted from an electron gun. The timing, dimensions, and microwave frequency are such that as the electron approaches an accelerating cavity (fig 5) the field is positive and attracts the electron. As the electron leaves the cavity (fig 6) the field changes and repels it. In both instances the electron receives accelerating energy. An important consideration here is that the electron rapidly reaches a constant velocity which is virtually the speed of light. Additional energy beyond that point serves to increase the mass of the electron rather than its speed. This property simplifies the construction, maintenance, and modification of the accelerator since the dimensions and timing remain constant once the electron reaches maximum velocity.

The systems shown here all use identical thyratron/klystron stations. The difference is that the linear accelerator is a multi-station system with each station connected to a common output.

System Characteristics. There are two important design characteristics to these systems:

Power. 1—Enormous power is used. Each stage has its own power supply and depending on the application, may dissipate up to 100 million watts of power in a few microseconds. 2—There are a large number of stages. One linear accelerator employs in excess of two hundred Thyratron-Klystron stages; another with over 900 is contemplated. This places great importance on component efficiency, since each stage involves high-power and is multiplied a great number of times in the system.

Precision. The system depends upon the precise timing of its elements. Two critical areas are:

Microwave Phase Alignment
The Turn-on Time of the modulators.

Precise phase alignment is achieved by adjusting the physical and electrical dimensions of the microwave equipment. Turn-on Time is an inherent characteristic of the thyratron and depends on its basic mechanism, specific design and product uniformity. Synchronization until now was achieved by a buffer delay which in effect blanks out part of the operation, and discards the power used during the delay. This point is discussed on the next page.

FIG. 5

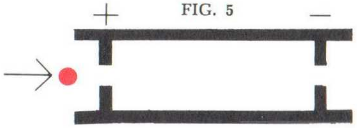


FIG. 6

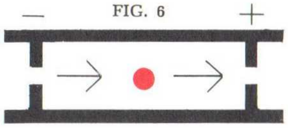
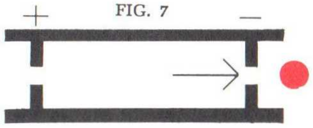
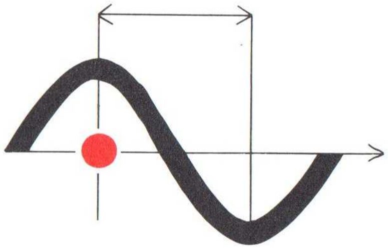


FIG. 7



PRECISION AND EFFICIENCY



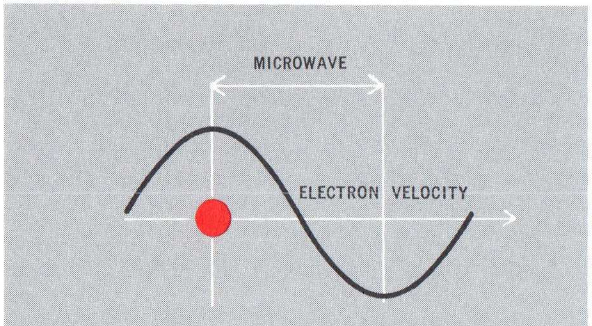


FIG. 8 MICROWAVE PHASE ALIGNMENT

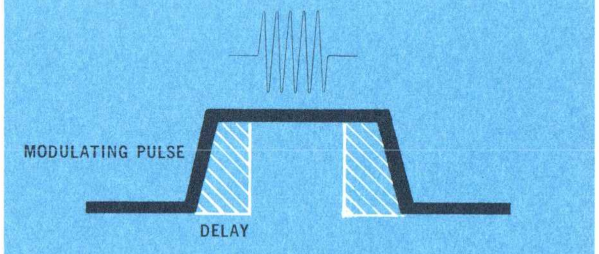


FIG. 9 POWER PULSE SYNCHRONIZATION

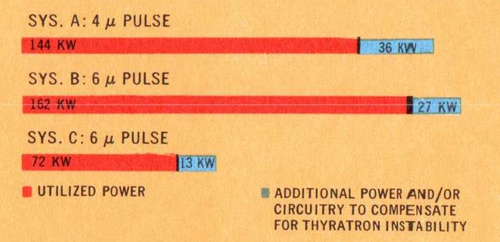


FIG. 10 UTILIZED POWER VS. TOTAL POWER

It has been pointed out that the synchronization of power pulses is as critical to the system as phase alignment. Particularly sensitive is the timing between the modulating pulse and the microwave drive. The microwave power must be applied during the flat portion of the pulse. To assure this, a delay is inserted between the triggering of the thyratron which produces the pulse and the application of the microwave power. And it is here that the shortcoming of the conventional thyratron is felt, for the delay must cover the three elements which make up the turn-on time of the thyratron:

1. Anode Delay Time. This is the interval between the initial trigger and final breakdown or conduction within the tube. In the conventional hydrogen thyratron it may be as great as 700 ns. The turn-on time of the tube is also affected by two forms of the tube instability—Drift and Jitter.

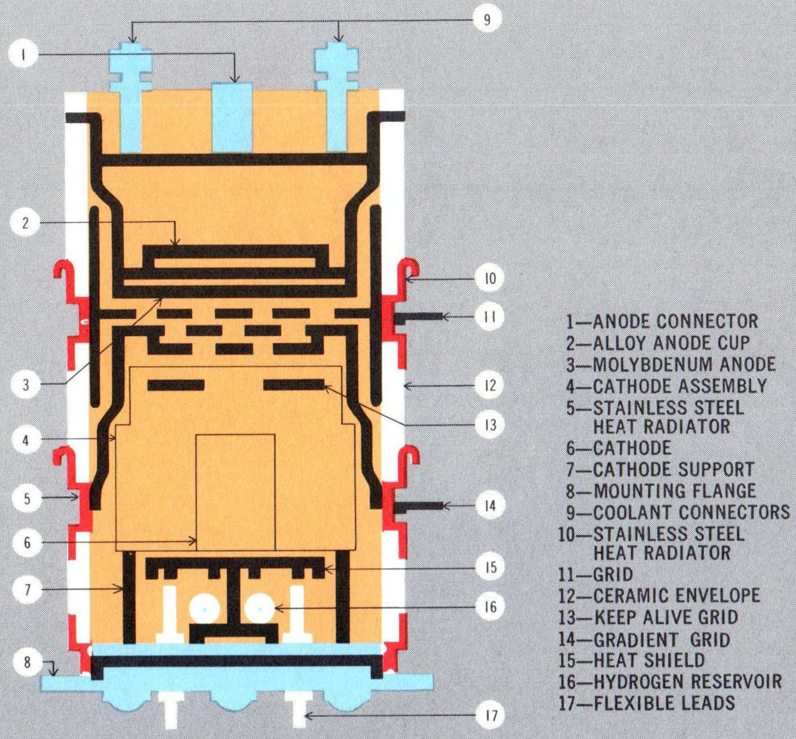
2. Drift. Drift or long term variation in switching time, is affected by the peak and average power being switched and is greatest during the initial period of operation. Drift may be as much as 20 percent of the delay.

3. Jitter. Jitter, or pulse-to-pulse variation in switching time, is small but significant in the operation of the overall system. By special circuitry and additional controls over the triggering pulse, jitter in the conventional thyratron can be reduced.

Additional Factors. Average power, manufacturing uniformity, temperature and aging all increase the total turn-on time of the conventional thyratron and thereby decrease its efficiency. Tube life is also an important consideration since it affects maintenance, replacement and system down-time.

Cost of Instability. The increase in anode delay due to drift and jitter in the conventional thyratron results in discarding about 420 nsec. of full thyratron power for each stage, each time the thyratron is pulsed. Depending on the system, peak pulse power can range from 3 to 100 megawatts. Now, since each thyratron is pulsed 360 times a second, and there can be as many as 240 per system, the additional power required to compensate for the instability of the conventional thyratron is considerable.

ULTRASTABLE HYDROGEN THYRATRONS



1—ANODE CONNECTOR
2—ALLOY ANODE CUP
3—MOLYBDENUM ANODE
4—CATHODE ASSEMBLY
5—STAINLESS STEEL HEAT RADIATOR
6—CATHODE
7—CATHODE SUPPORT
8—MOUNTING FLANGE
9—COOLANT CONNECTORS
10—STAINLESS STEEL HEAT RADIATOR
11—GRID
12—CERAMIC ENVELOPE
13—KEEP ALIVE GRID
14—GRADIENT GRID
15—HEAT SHIELD
16—HYDROGEN RESERVOIR
17—FLEXIBLE LEADS

FIG. 11 THE ULTRASTABLE HYDROGEN THYRATRON

This is the newest and most advanced ceramic Hydrogen Thyratron. It has been developed by the Tung-Sol Division of Wagner Electric to meet the increased demands for improved characteristics in ultra high power systems. In addition to the mechanical and electrical advantages of the ceramic hydrogen thyratron—high resistance to shock and vibration, superior thermal properties and high power handling capabilities—the new tubes have additional characteristics designed specifically for multi-station systems.

Uniformity. The Tung-Sol Ultrastable Thyratrons have a new order of uniformity from tube to tube which permits more efficient system design.

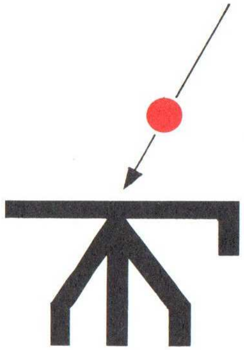
Keep Alive Grid. The chief feature of the new tubes is a keep alive grid which reduces the anode delay time and virtually eliminates drift and jitter. The increased speed and stability of the switching time permits simplified system design and significantly reduces power consumption.

Longer Life. Another advantage of the keep-alive grid is the significantly longer operating life which the new tubes display. Tubes are not discarded for poor time stability.

Proven Performance. The new tubes incorporate the best of proven basic designs. All the tested features of the Tung-Sol conventional Thyratrons, which contribute to stability, have been retained—the use of a gradient grid, for instance, in the ultra-high power units; to maintain an effective dc standoff at maximum forward voltage, and the titanium hydride reservoir; to insure a constant hydrogen density.

The advantages of the special features have been demonstrated both theoretically through a comparison of design and empirically by laboratory test results and operational history.

DESIGN ADVANTAGES



SWITCHING

The Tung-Sol Ultrastable Hydrogen Thyratrons have reduced the anode delay times of the conventional models by as much as 220 nanoseconds. In some systems this is better than 20% of the required modulating pulse.

This reduction in turn-on time is due to the inclusion of a special keep-alive grid inserted between the cathode and the switching grid. The advantage of this device can be seen from the comparison of the turn-on mechanism of the conventional thyratron and the ultra-stable unit.

The Conventional Thyratron. In order to permit the cathode to stand-off extremely high voltages, the hydrogen thyratron is constructed so that the anode field does not have direct access through the grid to the cathode. This is accomplished by a baffle placed between the control grid and the cathode. While this gives the tube positive grid control and serves to minimize grid emission, it also serves to complicate the turn-on mechanism as can be seen from Fig. 12.

Initially, the anode field is contained above the grid baffle and does not come into contact with electrons from the cathode. A pulse on the firing grid causes current to flow between the grid and the cathode which ionizes the region around the cathode structure (Fig. 12a). As this area becomes increasingly ionized, plasma forms over the grid structure (Fig. 12b). At some point during this period, the anode field will come in contact with the plasma and begin to ionize the region above the grid. This is quickly followed by a complete breakdown within the tube (Fig. 12c) and the thyratron acts as a closed switch.

From this, it can be seen that the turn-on of the conventional thyratron requires a preparatory step dependent upon a chance encounter to produce ions. It is this dependence on a statistical accident which results in the instability of the anode delay. This pulse-to-pulse variation in the thyratron turn-on time is called jitter.

The Ultrastable Thyratron. In the Tung-Sol Ultrastable Thyratron, the use of a keep-alive grid eliminates this dependence and virtually removes jitter and drift. (Fig. 13a) By keeping a small dc voltage constantly on this grid, the area between the grid and the cathode remains ionized. When the firing pulse is applied to the control grid, there are already ions available below the grid baffle. A transfer of the plasma takes place from the keep-alive electrode to the control grid. (Fig. 13b) The plasma diffuses through the space between the control grid and grid baffle into the influence of the anode field where breakdown takes place very quickly.

LONGEVITY

Another advantage of the keep-alive grid is that it adds an unusually long operating life to the unit. By maintaining a plasma in the area of the cathode structure, fewer high velocity particles strike the cathode surface and thereby increase the life of the tube.

These two theoretical advantages which can be inferred from the design of the tube, have been realized with unusual success in laboratory controlled tests and in actual operation. It is evident from the results obtained from the performance of these tubes that they can (1) significantly reduce the power consumption of multi-station systems and (2) simplify their design and effect sizable reductions in replacement and maintenance costs. The results of some of these tests are given on page 10.

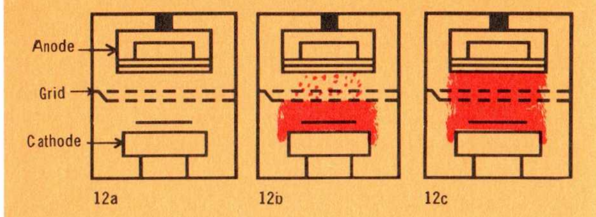


FIG. 12 CONVENTIONAL THYRATRON TURN-ON

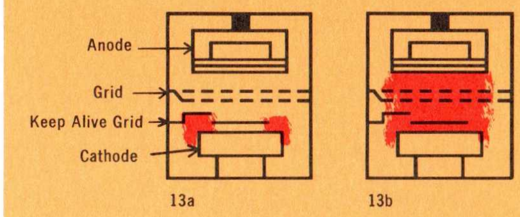


FIG. 13 ULTRASTABLE THYRATRON TURN-ON

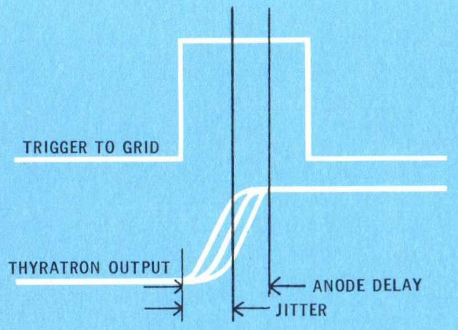


FIG. 14 CONVENTIONAL THYRATRON TURN-ON

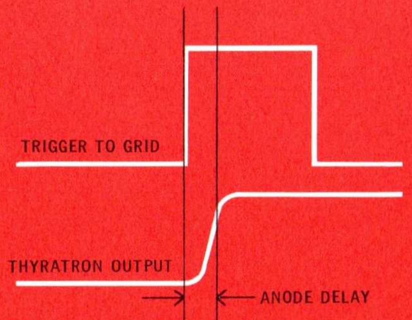
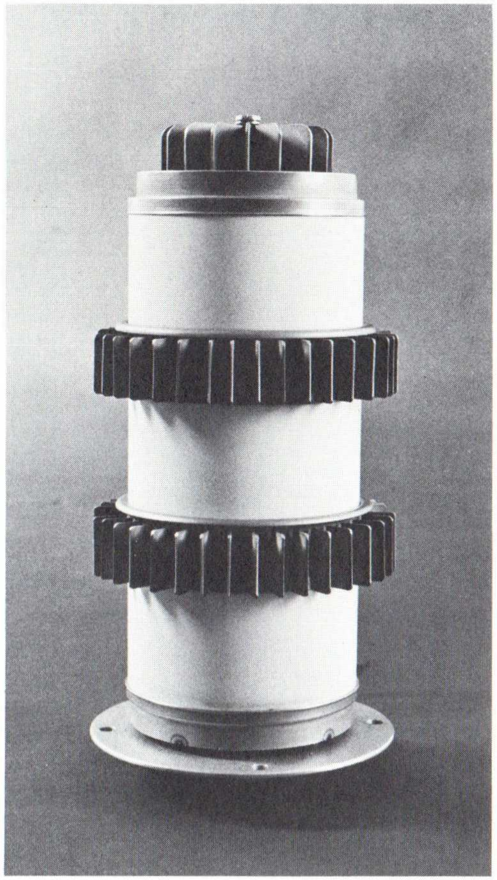


FIG. 15 ULTRASTABLE THYRATRON TURN-ON



TEST RESULTS

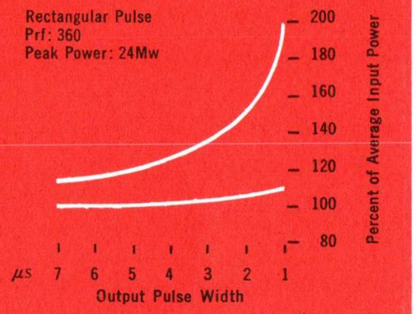


FIG. 16 EFFICIENCY INDEX

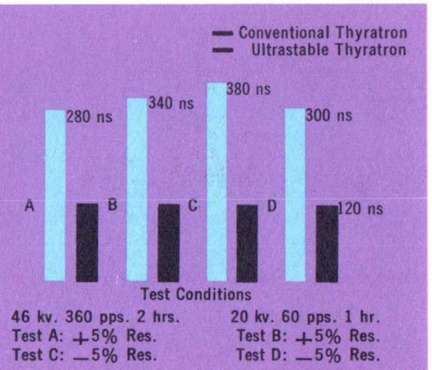


FIG. 17 ANODE DELAY VARIATION

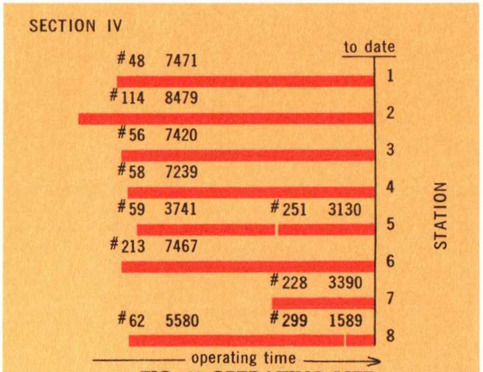


FIG. 18 OPERATING LIFE

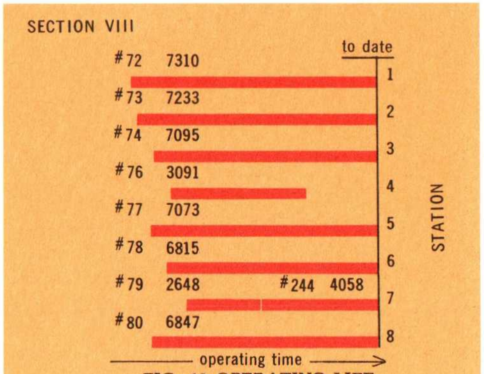


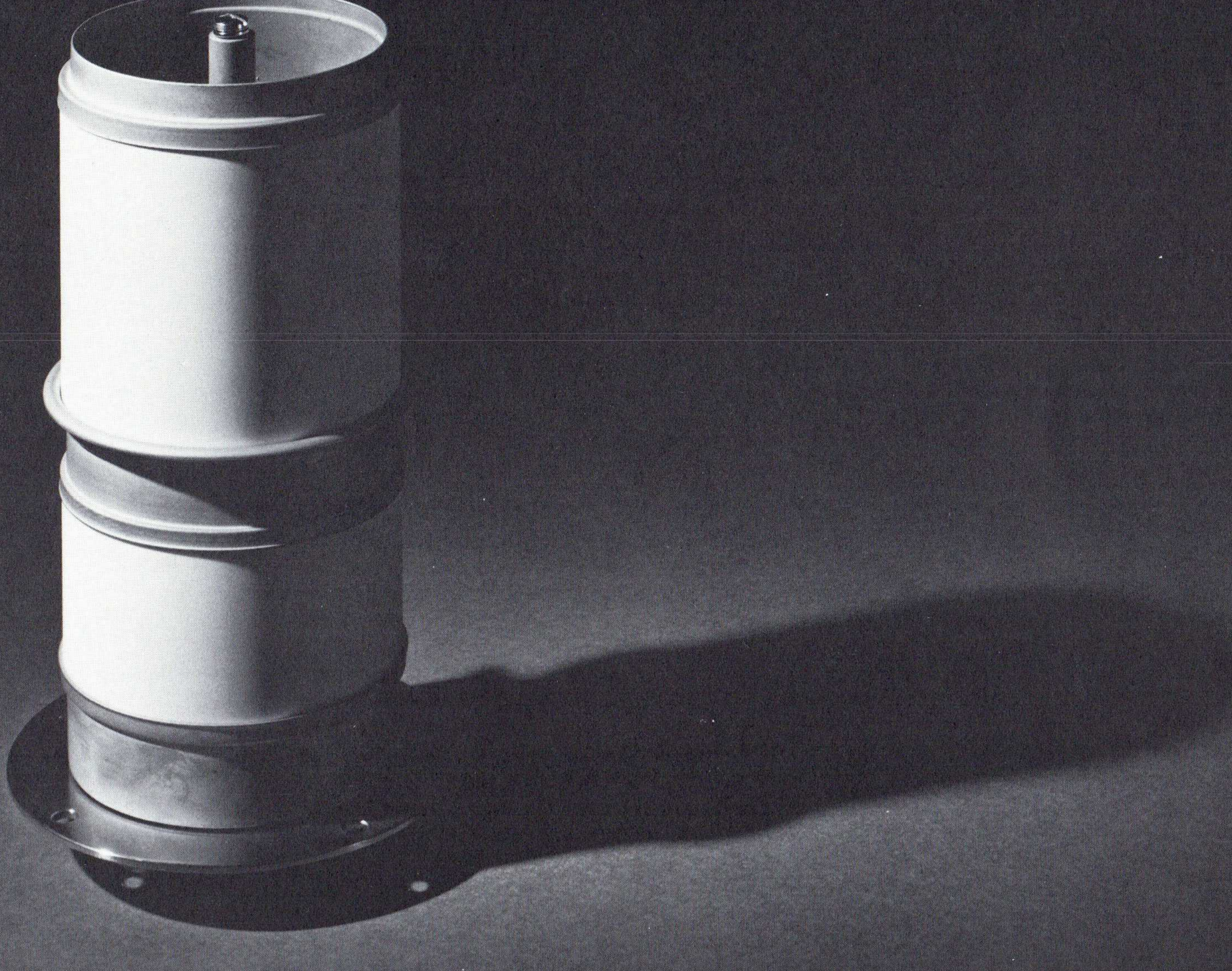
FIG. 19 OPERATING LIFE

The advantages which were predicted from the design of the ultra-stable hydrogen thyratrons have been established through tests and operational history. Efficiency, stability and life results appear in the charts on the left. Fig. 16 compares the efficiency of the new units with conventional thyratrons in a typical application. Fig. 17 demonstrates the turn-on time stability of the new units and the conventional thyratron under various conditions of high and low power. Figs. 18 and 19 show the operating history of the Tung-Sol thyratrons in two sections of a large research accelerator. They show to what extent performance has exceeded predictions. The original requirement for hydrogen thyratrons in this system was 2000 hours. Every Tung-Sol unit has exceeded this figure, and virtually all of them are still operating after periods ranging beyond 8000 hours.

SPECIFICATIONS

Thyratron Ratings	**CH1223**	**CH1198**	**CH1191**
po (Mw)	11.0	48.0	100.0
Pb (x 10)	10.0	55.0	400.0
epy (kV)	45.0	40.0	50.0
Ebb (kV dc min)	2.5	3.5	3.5
ib (Amp)	500	2400	4000
Ip (Amp ac)	15.0	7.5	170.0
Ib (Amp dc)	.500	4.0	8.0
epx (kV)	25.0	40.0	40.0
Keep-Alive Grid			
V dc max	100	300	300
mA dc max	50	250	500
Heater			
If (Amp ac max)	12.0	40.0	70.0
ER (V ac)	2.5-5.5	2.5-5.5	2.5-5.5
IR (Amp ac max)	2.5	12.0	15.0
Physical			
Ht. overall (In max)	7.25	14.4	17.5
Diameter (In nom)	2.60	5.25	8.00

CONVENTIONAL
HYDROGEN THYRATRONS
AND DIODES



CONVENTIONAL HYDROGEN THYRATRONS AND DIODES

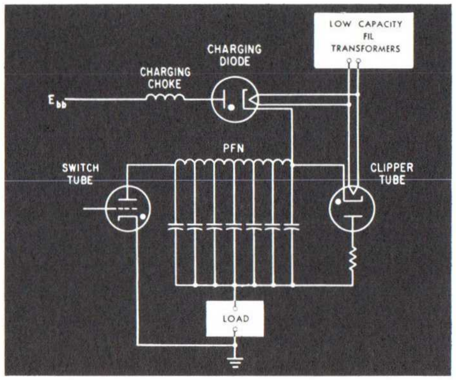
In addition to the newly developed ultra-stable hydrogen thyratrons, the Tung-Sol Division of Wagner Electric has developed a line of conventional power tubes, both ceramic and glass to cover the complete spectrum of applications from miniature airborne and missile requirements to space radar. These tubes have become industry standards for the following applications:

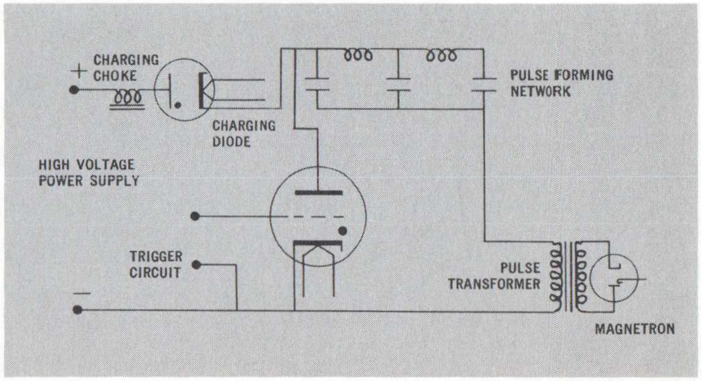
Power Supplies. Hydrogen diodes provide an effective means for high voltage rectification.

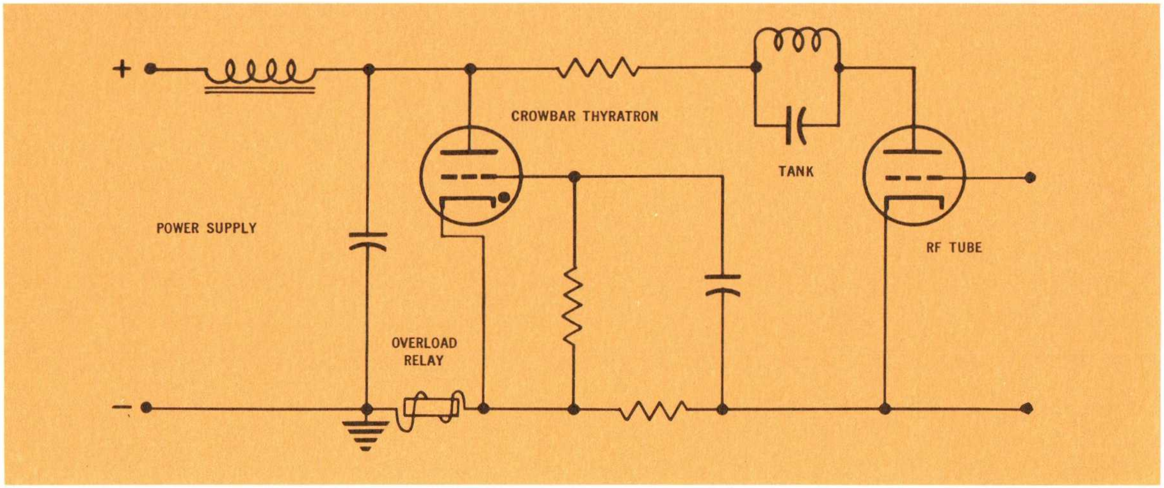
Pulse Modulators. In line type modulators, which do not require the ultra-stable thyratrons, Tung-Sol conventional thyratrons can handle peak power of 60 megawatts with a minimum of modulator stages and with high efficiency.

Clipper Circuits. Designed to stabilize modulator operation and to protect the components from surge voltages, the clipper circuit discharges the inverse voltage from the pulse forming network through a hydrogen diode. Tung-Sol hydrogen diodes cover the entire range of present day clipper circuits and power supply requirements.

Crowbar Circuits. Tung-Sol Crowbar Thyratrons provide arcing protection for every type of R.F. transmitting tube under a wide variety of operating conditions.







THYRATRONS

	THYRATRON RATINGS								HEATER			PHYSICAL	
TYPE	po Mw	Pb x10^9	epy kv	Ebb kVdc min.	ib a	Ip Aac	Ib Adc	epx kv	If Aac max.	ER Vac	IR Aac max.	ht. o.a. in max.	dia. in nom.
8191	.180	1.20	6.0	0.3	60	1.8	.050	6.0	3.5	I.C.	—	2.40	1.13
7621	.400	2.70	8.0	0.3	100	2.0	.100	8.0	3.5	I.C.	—	2.40	1.15
7782	1.0	3.5	10.0	10.0	200	5.0	.200	10.0	6.0	6.3	4.0	2.60	1.40
7665	3.5	4.0	16.0	16.0	350	6.5	.300	16.0	8.0	6.3	4.0	3.10	1.80
8036	6.25	6.25	25.0	3.0	500	15.0	.500	25.0	12.0	2.5-5.5	2.5	5.00	2.60
CH1180	11.0	10.0	45.0	2.5	500	15.0	.500	25.0	12.0	2.5-5.5	2.5	7.25	2.60
7322	12.5	20.0	25.0	1.5	1000	36.0	2.0	25.0	22.0	5.8-6.8	6.8	6.20	3.06
7390	33.0	30.0	33.0	3.5	2000	72.0	4.0	33.0	35.0	3.5-5.5	10.0	12.5	5.25
8326	60.0	55.0	33.0	2.5	4000	100.0	7.0	33.0	40.0	3.5-5.5	15.0	14.0	6.00
7890	48.0	55.0	40.0	3.5	2400	75.0	4.0	40.0	40.0	2.5-5.5	12.0	14.4	5.25

DIODES

	CLIPPER DIODE RATINGS					RECTIFIER RATINGS			HEATER				PHYSICAL	
TYPE	epx kv	ib a	Ib mAdc	ip Aac	epk v	epx kv	ib a	Ib Adc	Ef Vac	If Aac max.	ER Vac	IR Aac max.	ht. o.a. in.	dia. in max.
8373	12.0	60	50	1.8	100	12.0	1.0	0.25	6.3	3.20	I.C.	—	2.40	1.13
8374	15.0	100	100	3.3	100	15.0	2.0	0.50	6.3	4.75	I.C.	—	3.13	1.60
8375	25.0	200	300	7.7	125	20.0	4.0	1.0	5.0	12.0	5.0	3.0	6.00	2.60
8376	33.0	750	750	25.	125	25.0	8.0	2.0	5.0	16.0	5.0	4.0	7.80	3.06
8377*	33.0	2000	5000	60.	150	26.0	28.0	7.0	5.0	25.0	5.0	5.0	9.50	4.56
CH1188	40.0	2000	4000	60.	150	36.	16.0	4.0	5.0	25.0	5.0	10.0	11.50	4.56
CH1193	50.0	500	500	15.	250	50.0	6.0	1.5	5.0	15.0	5.0	4.0	7.00	3.06

*TENTATIVE RATINGS ALL TUBES LISTED ABOVE HAVE FLEXIBLE LEADS ALL THYRATRONS HAVE 6.3 VOLT HEATERS

CERAMIC

GLASS

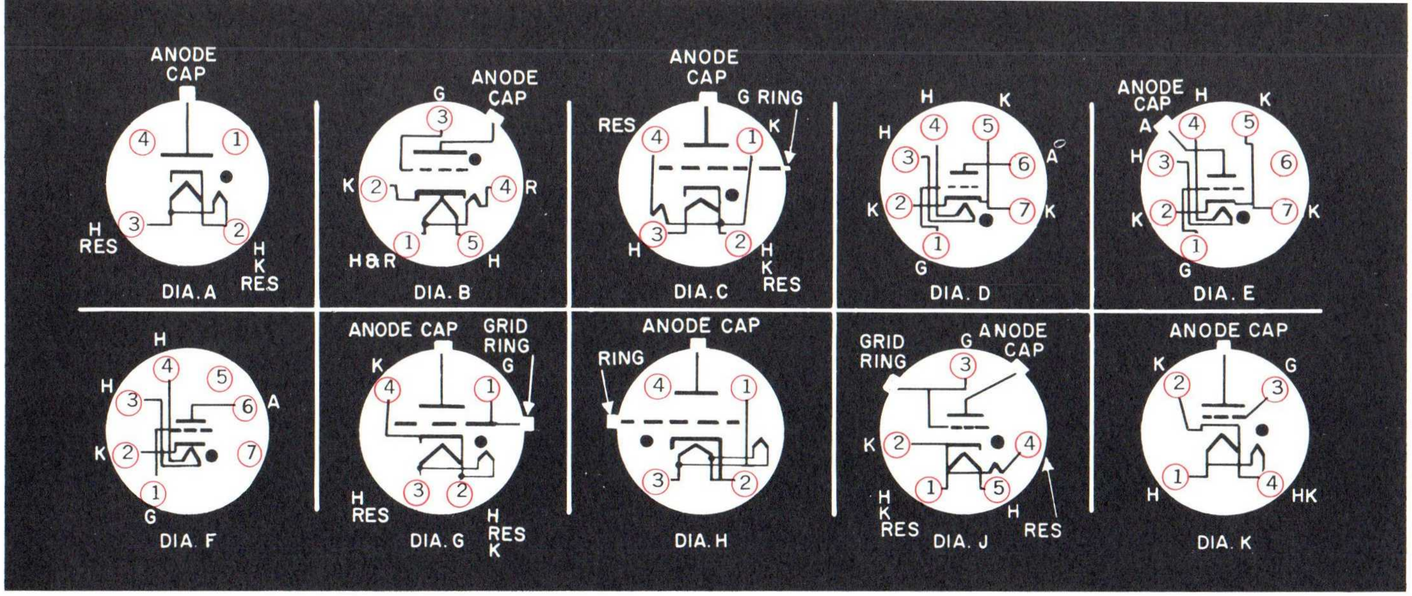
DISC SEAL DIODES

RATINGS		CLIPPER DIODE				RECTIFIER			HEATER				PHYSICAL		
	epx kv	ib a	Ib mAdc	Ip Aac	epk v	epx kv	ib a	Ib Adc	Ef Vac	If Aac max.	ER Vac	IR Aac max.	ht. o.a. in.	dia. in max.	Pin Conn
7789	13.0	150	200	5.5	100	15.0	1.6	0.4	5.0	9.3	I.C.	—	7.25	2.16	A
7790	25.0	200	300	7.7	100	20.0	4.0	1.0	5.0	12.5	I.C.	—	7.75	2.60	A
8434	—	—	—	—	—	20.0	8.0	1.8	5.0	13.8	I.C.	—	10.09	2.975	**
8435	—	—	—	—	—	20.0	8.0	1.8	5.0	13.8	I.C.	—	10.41	2.975	***
7791	33.0	750	500	20.0	125	25.0	8.0	2.0	5.0	17.0	I.C.	—	7.76	3.156	*
7792	33.0	750	500	20.0	125	25.0	8.0	2.0	11.5	10.5	I.C.	—	9.75	2.97	A
7793	33.0	1000	1.0	30.0	150	25.0	16.0	4.0	5.0	25.0	5.0	5.0	6.63	4.01	*

CLIPPER AND CROWBAR THYRATRONS

RATINGS		THYRATRON						HEATER				PHYSICAL		
	Ep KV	epx KV	ib a. fault	ib a.	Ip A.a.c.	Ib Adc	ib 50 MS a	Eh Vac	If Aac max.	ER Vac	IR Aac max.	ht.o.a. in max.	dia. in nom.	Pin. Dia.
7568	25.0	15.0	—	800	—	0.5	50	6.3	22.0	2.5-5.5	6.5	12.50	3.31	B
7590	25.0	15.0	—	1000	—	0.5	50	6.3	22.0	2.5-5.5	6.5	12.50	3.31	B
7454	—	25.0	1200	325	6.3	—	—	5.0	16.0	I.C.	—	7.25	2.56	H
8080	—	25.0	1200	325	6.5	—	—	5.0	10.5	3.5-5.0	5.0	7.25	2.56	C
7559	25.0	15.0	—	1500	—	1.0	100	6.3	33.0	2.5-5.5	6.5	16.25	5.13	*
7605	30.0	15.0	—	3000	—	2.5	180	6.3	40.0	3.5-6.0	12.0	20.87	7.13	*
7455	—	33.0	2900	800	16.0	—	—	5.0	25.0	I.C.	—	8.70	3.70	*

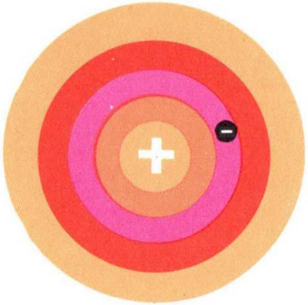
* FLEXIBLE LEADS ** REPLACES MERCURY VAPOR TYPE 6894 AND 575A *** REPLACES MERCURY VAPOR TYPE 6895 AND 673



THYRATRONS

RATINGS	THYRATRON							NETWORK	HEATER			PHYSICAL		
	po Mw	Pb $x10^9$	epy kv	Ebb kVdc min.	ib a	Ip Aac	Ib Adc	Zn Ohms nom.	If Aac max.	ER Vac	IR Aac max.	ht.o.a. in max.	dia. in max.	Pin. Conn
1258	.008	0.1	1.0	.30	20.0	1.0	.050	25	2.0	None	—	2.18	.87	D
7190	.010	0.10	1.2	.30	20.0	1.0	.050	30	2.0	None	—	2.13	.85	D
7191	.010	0.10	1.2	.30	20.0	1.0	.050	30	2.0	None	—	2.42	.85	E
7192	.010	0.10	1.2	.30	20.0	1.0	.050	30	2.0	None	—	2.75	.85	F*
7240	.010	0.10	1.2	.30	20.0	1.0	.050	30	0.46†	None	—	2.13	.85	D
8097	.010	0.10	1.2	.30	20.0	1.0	.050	30	0.46†	None	—	2.42	.85	E
7191A	.020	0.22	2.2	.30	20.0	1.0	.050	55	2.0	None	—	2.48	.85	E
E38	.220	1.25	5.0	.30	90.0	3.0	.100	27	6.7	I.C.	—	4.75	1.70	K
5957/E37B	.330	2.5	8.0	1.5	83.0	2.9	.100	50	6.7	I.C.	—	4.37	1.56	K
6587	2.0	3.9	16.0	3.5	325.	6.3	.225	—	11.6	I.C.	—	7.25	2.56	G††
7872	3.20	5.0	18.0	3.0	365.	7.0	.250	—	9.0	3.0-6.8	4.0	6.00	2.56	J
8253	3.50	5.0	20.0	3.5	365.	7.0	.250	—	12.0	I.C.	—	6.00	2.56	G
5949A/1907A	6.00	6.25	25.0	5.0	500.	15.8	.500	25	22.0	3.0-5.5	5.0	12.50	3.31	B
5948A/1754A	12.00	9.0	25.0	5.0	1000.	31.8	1.0	12.5	33.0	2.5-5.5	6.0	16.25	5.12	*
1257	33.00	20.0	33.0	3.5	2000.	60.0	2.6	8.3	30.0	3.5-6.0	8.0	20.87	7.12	*

†26 VOLT HEATER. ALL OTHERS HAVE 6.3 VOLT HEATERS ††NO GRID RING *FLEXIBLE LEADS



For further information and assistance contact the Thyratron Applications Group, Tung-Sol Division/Wagner Electric Corporation, Livingston, N.J. (201-992-1100) or one of the following sales offices:

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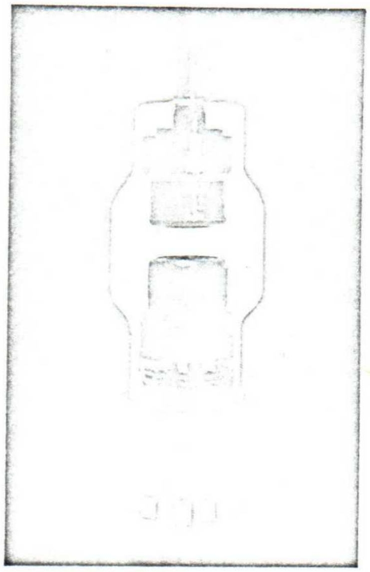
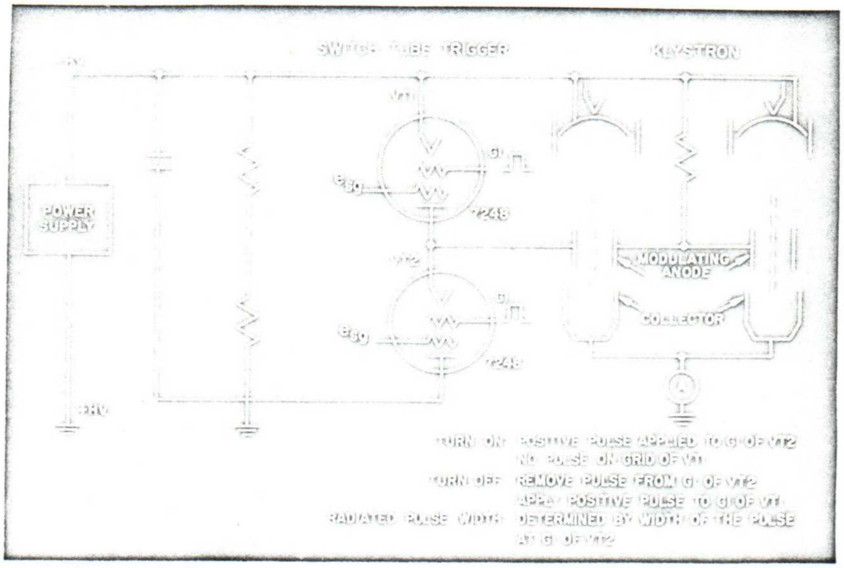
POWER TUBES





TYPES 7248 AND 7249

The 7248 and 7249 are high voltage vacuum switches which provide the extremely high speed turn-on and turn-off capability required by coded pulse applications. The tubes are tetrodes with precision made grids accurately indexed so that the screen grid falls exactly in the shadow of the control grid. This prevents over-heating and results in sharper control. The filament in both tubes is in the form of a flat spiral coil positioned exactly parallel to the plane of the grids. This assures a constant amplification factor across the area of the grids—another element contributing to the control characteristic of the tube. The 7249 incorporates a radiator for increased plate dissipation.

The primary application of these tubes, as shown in the diagram, is to trigger the modulating anode of the klystron in floating deck modulators. They can, however, find wide application wherever high repetition rate high voltage switching is required.

ELECTRICAL	**7248**	**7249**
FILAMENT VOLTAGE	6.3 VOLTS	6.3 VOLTS
FILAMENT CURRENT	12 AMPS	12 AMPS
DC PLATE VOLTAGE	125 KV	125 KV
DC SCREEN GRID VOLTAGE	1.5 KV	1.5 KV
DC CONTROL GRID VOLTAGE	—600 VOLTS	—600 VOLTS
PEAK CATHODE CURRENT	2.0 AMPS	2.0 AMPS
PLATE DISSIPATION—IN OIL	200 WATTS	500 WATTS
PHYSICAL		
HEIGHT OVERALL (MAX)	9 15/16 INCHES	13 7/16 INCHES
DIAMETER (MAX)	3 5/8 INCHES	3 5/8 INCHES

Tung-Sol maintains a continuing investigation into the use and improvement of hydrogen and vacuum power tubes. An experienced applications staff is available at all times to quote or advise on standard or developmental versions of these components. For further information contact Tung-Sol Electric Inc., Power Tube Division, Livingston, New Jersey.

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