TELEVISION RECEIVER CONSTRUCTION

LIEBSCHER

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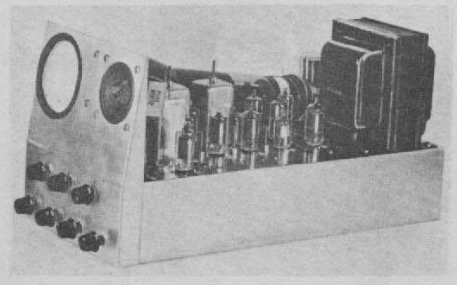

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INTRODUCTION

TELEVISION is destined to become a great industry within the span of this generation. Its influence will affect the entertainment, the business and the domestic life of millions of its patrons.

The development of so extensive a market will also demand the growth of services to maintain this equipment in satisfactory operating condition. Anticipating the need for an extensive training program in this field educators are writing books, publishing magazines, and delivering lectures, in an effort to ground future service men in the principles of television.

The object of this book is to explain, through specific examples, a means of constructing a typical low cost television receiver and thereby provide practical experience to supplement other training activities.*

It is hoped that the constructor in building, testing and operating this receiver, will become familiar with the basic principles of television receiver design, then apply his knowledge toward mastering the more complex circuits as they are encountered.

While the schematic diagram and other pertinent information contained in this text is intended to guide the constructor in building his own television receiver, it also affords a comprehensive insight into the method of assembly practiced by manufacturers.

Popular demand for a training kit which even beginners could make work successfully, prompted the method of instruction found in the following chapters. The 197 major parts and 18 tubes, of which the kit consists, can easily be assembled by faithfully following the 243 operations listed in the construction procedure.

In schools where it is desirable to teach mass production methods, a number of receivers can be built simultaneously. Under these circumstances each trainee is assigned one operation which he carries to completion on the entire group of sets before reporting back for a subsequent assignment.

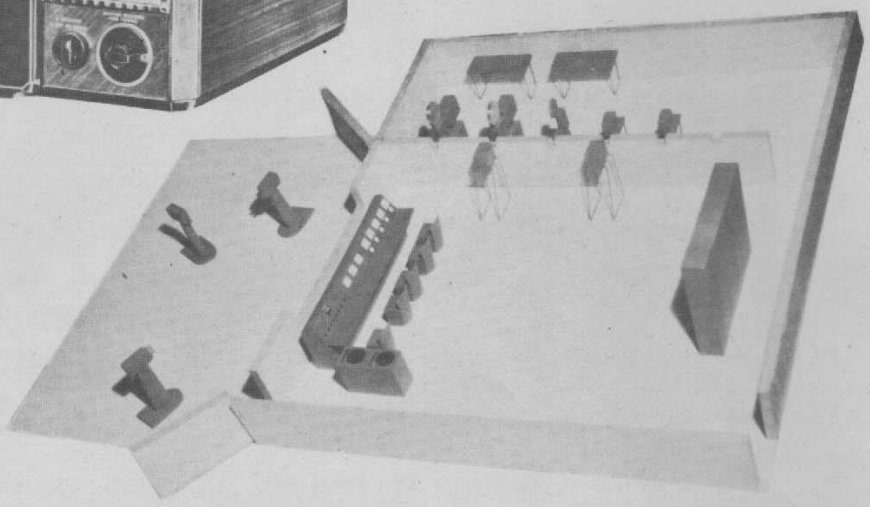
This method of construction was tried in an evening technical school in the Spring of 1947 and all ten receivers so constructed operated satisfactorily.

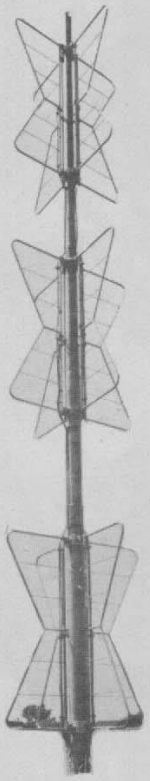
In order to help those who desire to do a construction job in keeping with standard practices of good workmanship, notes on soldering together with other helpful advice on construction details have been included.

Elementary explanations of "How Television Works" and similar information are intended to assist the student constructor starting on the road toward a proficient reading of schematic diagrams and the mastery of a product of his own hands.

* *Various television circuits and parts are patented, including some described in this booklet, and consideration should be given to patent rights.*

Students Assembling Television Receivers By Production Methods





Photos — Courtesy of RCA

CHAPTER I

HOW TELEVISION WORKS

The television receiver serves to convert weak antenna signals to a complete sight and sound reproduction of an original studio or "remote" scene.

The picture and sound signals are broadcast with a definite carrier frequency relationship and because of the particular circuit employed, the choice of any television picture automatically engages the corresponding sound accompaniment. It is possible, therefore, to switch from one television channel to another, by the selection of previously fixed-tuned circuits and expect co-ordinated pictures and sound.

Both the picture signal and the sound signal are simultaneously received by a single antenna system and tuned by a common station selector circuit. After that the picture and sound signals are separated into their respective amplifying channels and they never meet again until they are co-ordinated by the observer's own vision and hearing as the actual picture image and its accompanying sound. As in the movies, the illusion of motion is produced by a rapid sequence of slightly different still pictures. An ever-changing series of complete but temporary television pictures brings the original motion to the observer.

In order to reproduce the sound component of a television broadcast, every television receiver contains in addition to the picture receiving circuit, a high frequency f-m sound receiver circuit.

Reviewing some of the theory of transmitting sound by radio, we find that all the complex sounds we hear are actually composed of a series of air pressure waves varying in tone (frequency) and loudness. These sound waves are in turn converted to electrical waves for transmission and then back again to sound waves. This means we are able to transmit one tone component after another by radio and cause them to finally flow forth in the same sequence which composed the original sound.

In order to transmit a picture, it too must be broken down into many sequential signals and reconstructed in an orderly pattern. Purposely then, the received television image contains both light and dark elements, which correspond to the same relative points in the original scene.

A close look at any newspaper photograph will reveal that black ink dots on white paper blend to form pictures with various degrees of shading.

The television way of taking a picture apart to produce "video" signal variations for transmission, is by tracing line after line of a series of light and dark portions across a picture, from top to bottom, and varying the signal amplitude in accordance with those light and dark portions.

In the receiver the picture or video signal is sufficiently amplified and detected as the same sort of electrical signal that left the television camera. It is then impressed on the cathode-ray picture reproducing tube, where the picture signal controls the intensity of each reproduced light or dark element in the final fluorescent image.

"Scanning" is essential to the reconstruction of the television picture and it is accomplished in the receiver by two oscillator circuits; one for horizontal and one for vertical deflection of the electronic pencil point, which is actually the cathode-ray beam.

The scanning process may be more readily understood by placing a paper over a coin and then using a pencil to trace enough straight lines to cause the image on the coin to appear on the paper. This is an old trick but it illustrates how the moving dot at the pencil point can form a whole picture, through the use of straight lines alone.

Deflection of the cathode-ray beam itself could not be controlled well enough to form a picture with each element in its proper place, were it not for the use of common synchronizing or timing pulses. These pulses are used to precisely associate every action of the camera tube's scanning with the scanning of all cathode ray reproducing tubes attuned to the same signal. The synchronizing pulses coming from the television transmitter influence the scanning action to a degree where it holds each horizontal line and each vertical picture "frame" in place.

One can appreciate the need for the number of tubes required in a television receiver when it is realized that a built in sound receiver is only one of the units associated with the other major sections, namely; the picture signal amplifier, the scanner, the timer, the power supply and the picture reproducing units.

CHAPTER II

PRECAUTIONS

Before proceeding with the actual construction of a television receiver it is well that the constructor become familiar with safety precautions repeatedly emphasized in the various television manufacturers' instruction books.

Mechanical Precautions

Safety glass is almost universally used on commercial television receivers to protect the viewer from any possible implosion of the cathode ray tube, which is in part the screen of modern electronic television.

The handling of cathode ray tubes should only be done by those familiar with the fact that they are highly evacuated and that any impact may cause the glass to crack. Instruction books advise the service man to wear gloves and goggles as an added precaution while installing cathode ray tubes, particularly the larger ones.

Although many thousands of three and five inch tubes are used in oscilloscopes without additional glass protection, it may be pointed out that the use of a heavy lens with such tubes in video service not only serves its purpose of enlargement, but acts as a protection as well.

As a further safety measure outdoor antenna installations should be designed not only for good television reception, but also for their ability to withstand severe windstorms and heavy icing conditions. This means that the supporting pole must be staunch enough not to bend or slip under an abnormal load. Guy wires and their anchorage should be strong enough to show no strain under a good shaking test. Where guy wires are fastened to a pole, mechanical security against slipping can be assured by drilling a small hole through the pole to accommodate a cross pin or securing wire. The transmission line or lead in should preferably be placed to prevent its being encrusted with heavy icicles or its being whipped about in the wind. Never cross a power-line with a lead-in or place an antenna where it could be blown against one.

Electrical Precautions

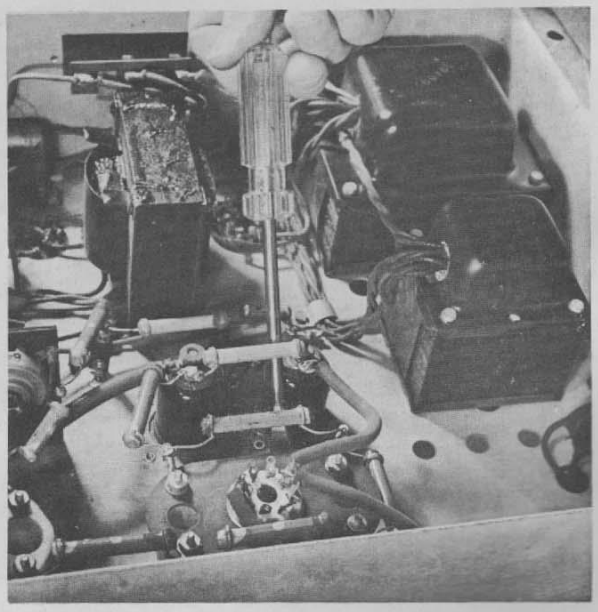
In order to make the cathode ray tube operate it is necessary to apply a high voltage to its elements. This voltage varies with the size of the tube from approximately 1200 volts for a three inch tube to 8000 volts for a twelve inch tube and where projection type tubes are used, voltages in the order of 30,000 are employed. As in the case of automobile ignition systems, however, the high voltage used in most postwar television receivers is limited to a very small amount of current. This indicates that the normal electrical resistance of the body would tend to drop the voltage to a harmless level on contact. It must be remembered that the above applies only to television receivers employing the reactance system of producing the high voltage component and that the power transformer system, while restricted to proportionately lower voltages, can deliver more current.

A study of voltages by the Electrical Bureau of New York incidentally, disclosed that 95% of all accidents are from low voltage types of appliance and apparatus.

Radio receivers which develop about 250 volts d.c. in their internal wiring, have not proven hazardous in the hands of radio service personnel and with a fair knowledge television power supply circuits, radio and electronic technicians should be able to work with higher voltages as well.

A knowledge of underwriter's requirements plus the general practice of handling all television receivers with full safety precautions will serve as the best preventative medicine.

As all parts look the same whether they are charged with high voltage or not it is a safe rule NEVER to work on the under side of a chassis or touch the cathode ray tube socket contacts when the set is operating. ALWAYS disconnect the power line plug and then discharge the high voltage capacitors with a solid insulated handle screw driver before touching or working on any internal parts.



When short circuiting the capacitors put one hand behind you and holding the screw driver well up the handle with

the other, place its tip on the metal chassis ground first and then lean the stem over to make contact with the capacitor lead. When working on the chassis it is important that this safety precaution be taken after each time that power has been applied, even though the charge has on previous occasions leaked off through the voltage divider system.

When constructing the television receiver it is good practice to make the connections of the primary leads of the power transformer last.

One more note of caution: remember that children or inexperienced people may become curious and expose themselves to dangerous contacts when least expected and for this reason it is well to keep a bottom plate on the chassis at times when a technician is not working on it.

CHAPTER III

TOOLS AND EQUIPMENT

One of the objects considered in the design of the miniature television receiver described herein was to keep the tool and test equipment requirements to a minimum. Hence, the tools found in the average radio service shop, school or most home work shops are usually ample.

Since a full complement of required tools plays an important part in the production of a first class assembly job the following list is included for convenience in checking those items which the constructor may already have. Assurance of their availability will help to avoid delays during the assembly of the chassis.

Suggested Tool List

1 — small screw driver
1 — medium screw driver with insulated handle.
1 — pair of long nose pliers.
1 — pair of diagonal cutters.
1 — pair of gas pliers.
1 — pair of 5 inch pointed tweezers.
1 — scriber.
1 — half inch end wrench.
1 — small 25 watt electric soldering iron.
1 — 100 watt electric soldering iron.
1 — dental mirror.
1 — insulated aligning tool.

The last item should have a screw driver end on a quarter inch bakelite rod and it should include a sleeve over the driver end to keep it centered on No. 6 iron core adjustment screws.

An Electronic Voltmeter and a Test Oscillator are the only Instruments Needed For Alignment

Test Equipment

The system of staggered tuning employed in the picture i-f stages of the television set described herein makes the problem of band pass amplifier adjustment relatively easy since it requires only the use of a radio servicing type test oscillator with a range up to 30 megacycles and an electronic voltmeter.

Sweep alignment equipment, if available, may be used to improve the overall i-f response but usually the maximum performance can be adequately checked on a small receiver by use of a test pattern, as broadcast at intervals by most television stations.

As explained later the same test oscillator and voltmeter can be used to align the sound i-f amplifier and discriminator. Harmonics of the test oscillator will serve to help tune up the r-f and oscillator sections of the receiver pending final adjustment when a picture is being received.

The use of an oscilloscope and additional test equipment is required only if results are unsatisfactory or if it is desired to study the signals and wave shapes present in the receiver.

CHAPTER IV

PARTS LIST

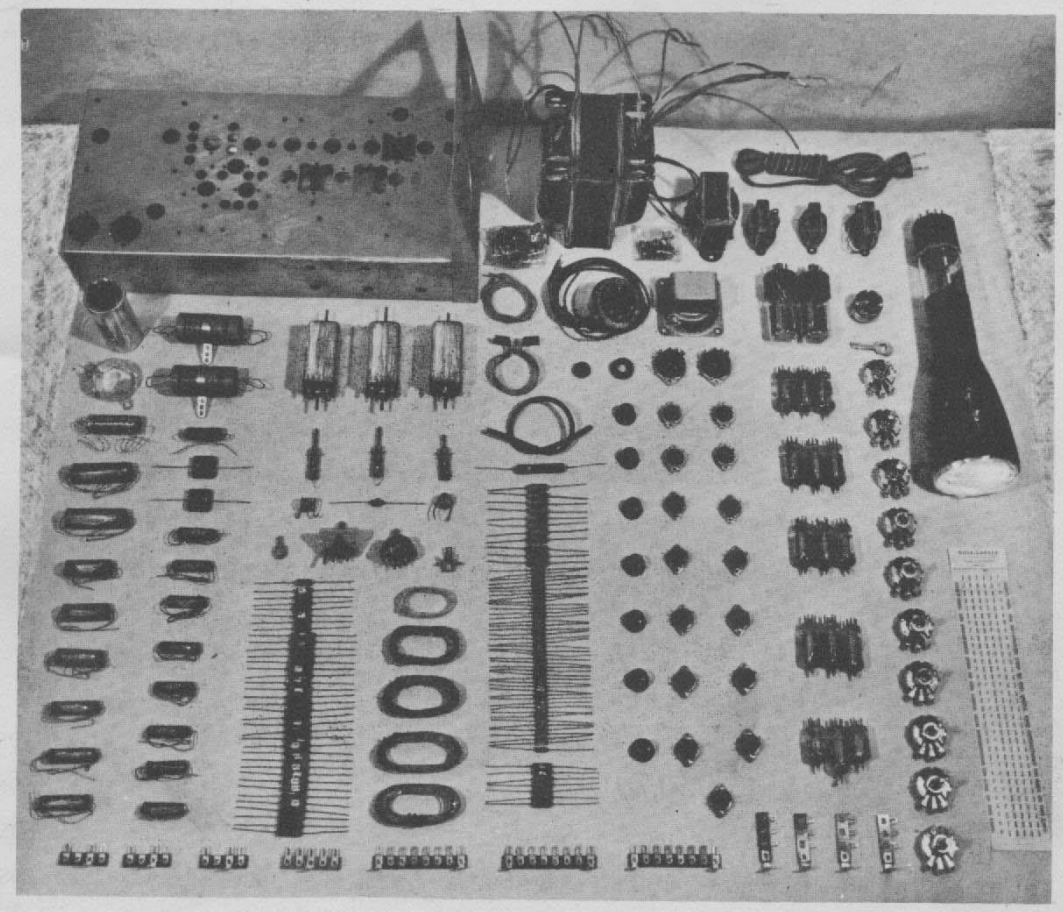
In obtaining parts for the miniature television receiver care should be exercised in duplicating as many as possible of the original components used in the design models.

Because of the compactness of layout, the size of some items becomes an important factor. This is evidenced in the use of a number of 400 volt paper capacitors in lieu of the usual 600 volt size. It is further true of the i-f transformers, which for the sake of maintaining short leads are placed directly next to their associated tubes. If a neat wiring job is expected all resistors and ceramic capacitors must be of the insulated type and they must also be small enough to allow room for other nearby parts.

From the standpoint of electrical qualifications, little need be said about the importance of obtaining i-f coils and transformers which can be relied on to tune properly when a signal is applied. The power and a-f transformers too, must be selected for their conformance to the original types. The resistance curves of volume controls are, in most cases, as important as their overall value.

With the foregoing in mind, substitutions can be made if desirable or necessary, providing they are directly interchangeable physically and also of equivalent electrical value.

The following is a comprehensive parts list which contains numerous items presently carried as standard replacement parts by local electronic parts distributors.



A Complete Set of Parts Consisting of 197 Components, 18 Tubes and Hardware

Item	Quantity	Description	Suggested Supplier	Type
1	1	Capacitor — 4.7 mmfd. ceramic	Erie Resistor	NPOK4.7
2	2	Capacitor — 6.8 mmfd. ceramic	Erie Resistor	NPOK6.8
3	1	Capacitor — 8.2 mmfd. ceramic	Erie Resistor	NPOK8.2
4	1	Capacitor — 10 mmfd. ceramic	Erie Resistor	NPOK 10
5	1	Capacitor — 15 mmfd. ceramic	Erie Resistor	NPOK 15
6	1	Capacitor — 56 mmfd. ceramic	Erie Resistor	N750 56
7	1	Capacitor — 500 mmfd. ceramic	Erie Resistor	GP2K 500
8	29	Capacitor — 1000 mmfd. ceramic	Erie Resistor	GP2L 1000
9	1	Capacitor — 4-20 mfd. 450v. electrolytic	Spreague	8348
10	1	Capacitor — 25 mfd. 25v. electrolytic	Spreague	8347
11	2	Capacitor — .1 mfd. 1600v. oil filled	Aerovox	1689M
12	1	Capacitor — .002 mfd. 1600v.	Aerovox	1684
13	1	Capacitor — 820 mmf. mica	Aerovox	1467
14	1	Capacitor — 1500 mmf. mica	Aerovox	1467
15	4	Capacitor — .005 mfd. 600v. paper	Aerovox	684
16	5	Capacitor — .01 mfd. 600v. paper	Aerovox	684
17	3	Capacitor — .05 mfd. 400v. paper	Aerovox	484
18	3	Capacitor — .1 mfd. 400v. paper	Aerovox	484
19	2	Capacitor — .25 mfd. 400v. paper	Aerovox	484
20	1	Capacitor — variable		*
21	1	Chassis — complete with base plate		*
22	1	Choke — filter (L-7)		*
23	1	Clamp — C.R. Tube		*
24	1	Clamp — capacitor mounting		*
25	1	Coil — peaking (L-6)		*
26	3	Coil — pix i-f (L-3, L-4, L-5)		*
27	1	Coil — antenna (L-1)		*
28	1	Coil — oscillator (L-2)		*
29	1	Control — variable res. 10,000 ohm	I.R.C.	DS-14-116
30	2	Control — variable res. 50,000 ohm	I.R.C.	DS-11-123
31	1	Control — variable res. 100,000 ohm	I.R.C.	DS-11-128
32	1	Control — variable res. 250,000 ohm	I.R.C.	DS-11-130

* *Designates items available from Electronic Parts Distributors, supplied by Espey Mfg. Co., N. Y.*

Item	*Quantity*	*Description*	*Suggested Supplier*	*Type*
33	4	Control — variable res. 500,000 ohm	I.R.C.	DS-11-133
34	1	Control — variable res. 2 megohm	I.R.C.	DS-13-139
35	1	Cord — power	Belden	1725
36	2	Grommets		*
37	1	Jack — ant. connector (J-1)		*
38	7	Knobs		
39	1	Mounting gasket — C.R. Tube		*
40	1	Plug — ant. connector		*
41	5	Resistor ½w 68 ohm	I.R.C.	BW½
42	1	Resistor ½w 100 ohm	I.R.C.	BW½
43	1	Resistor ½w 120 ohm	I.R.C.	BW½
44	8	Resistor ½w 1000 ohm	I.R.C.	BTS
45	1	Resistor ½w 3300 ohm	I.R.C.	BTS
46	1	Resistor ½w 3900 ohm	I.R.C.	BTS
47	1	Resistor ½w 5600 ohm	I.R.C.	BTS
48	3	Resistor ½w 6800 ohm	I.R.C.	BTS
49	1	Resistor ½w 8200 ohm	I.R.C.	BTS
50	3	Resistor ½w 10,000 ohm	I.R.C.	BTS
51	1	Resistor ½w 24,000 ohm	I.R.C.	BTS
52	1	Resistor ½w 33,000 ohm	I.R.C.	BTS
53	5	Resistor ½w 100,000 ohm	I.R.C.	BTS
54	2	Resistor ½w 220,000 ohm	I.R.C.	BTS
55	2	Resistor ½w 330,000 ohm	I.R.C.	BTS
56	3	Resistor ½w 470,000 ohm	I.R.C.	BTS
57	1	Resistor ½w 820,000 ohm	I.R.C.	BTS
58	4	Resistor ½w 1 megohm	I.R.C.	BTS
59	1	Resistor ½w 1.5 megohm	I.R.C.	BTS
60	4	Resistor ½w 2.2 megohm	I.R.C.	BTS
61	2	Resistor ½w 10 megohm	I.R.C.	BTS
62	1	Resistor 1w 2200 ohm	I.R.C.	BTA
63	1	Resistor 1w 3300 ohm	I.R.C.	BTA
64	1	Resistor 1w 10,000 ohm	I.R.C.	BTA
65	1	Resistor 1w 15,000 ohm	I.R.C.	BTA
66	1	Resistor 1w 33,000 ohm	I.R.C.	BTA

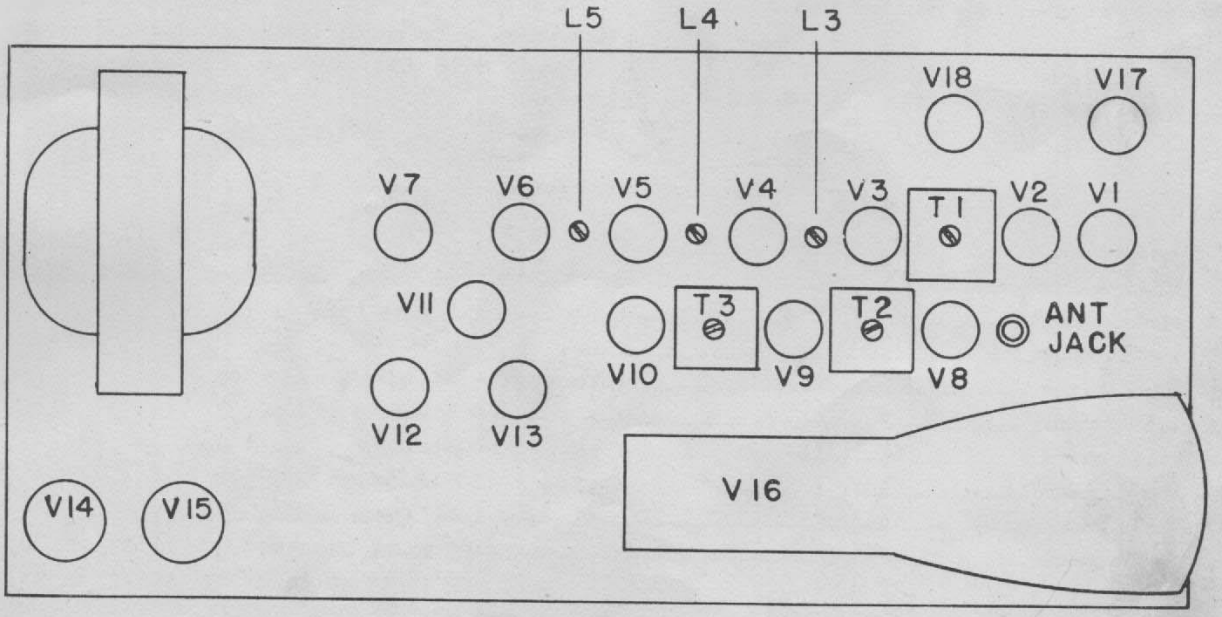
Item	*Quantity*	*Description*	*Suggested Supplier*	*Type*
67	6	Resistor 1w 47,000 ohm	I.R.C.	BTA
68	1	Resistor 2w 8,200 ohm	I.R.C.	BT2
69	4	Screws, nuts and lockwashers		10-32
70	2	Screws, nuts and lockwashers		8-32
71	38	Screws, nuts and lockwashers		6-32
72	30	Screws, nuts and lockwashers (*not required if sockets are riveted*)		4-36
73	1	Socket — magnal, with leads (V-16)		*
74	15	Socket — miniature (V-1 to V-13 V-17, V-18)		*
75	2	Socket—octal (V-14, V-15)		*
76	1	Speaker — 2″ P.M. (S-3)		*
77	1	Switch — power: control mounting (S-2)	I.R.C.	41
78	1	Switch — selector (S-1)		*
79	3	Terminal strip — 2 pt. & gnd. (TS-1, TS-7, TS-10)		*
80	1	Terminal strip — 4 pt. & gnd. (TS-9)		*
81	3	Terminal strip — 6 pt. & 2 gnd. (TS-2, TS-3, TS-4)		*
82	4	Terminal strip — vertical 3pt. (TS-5, TS-6, TS-8, TS-11)		*
83	1	Transformer — Horiz. osc. (T-4)		*
84	1	Transformer — Vert. osc. (T-5)		*
85	1	Transformer — 1st i-f (T-1)		*
86	1	Transformer — Sound i-f (T-2)		*
87	1	Transformer — Discriminator (T-3)		*
88	1	Transformer — Output (T-7)		*
89	1	Transformer — Power (T-6)		*
90	1	Wire assortment — 6 color		*

NOTE: The controls, tuning capacitor and band switch may be supplied with various shaft lengths. Normally all shafts can be cut to extend one half inch beyond the threaded shank. If mounting the set in a cabinet is contemplated, the shaft lengths should be cut according to cabinet panel requirements. Screw driver slots in the shafts of the side mounted controls will facilitate their adjustment.

Tube Complement

1 — 3KP1*	Cathode Ray Picture Tube	V-16
2 — 5Y3GT	Low Voltage Rectifier	V-14
	High Voltage Rectifier	V-15
1 — 6AK6	Audio Output	V-18
2 — 6AL5	Video Detector	V-6
	Audio Discriminator	V-10
3 — 6AU6	2nd Sound i-f amplifier	V-9
	1st audio amplifier	V-17
	Video Output	V-7
5 — 6BA6	Mixer	V-2
	1st Sound i-f amplifier	V-8
	1st pix i-f amplifier	V-3
	2nd pix i-f amplifier	V-4
	3rd pix i-f amplifier	V-5
1 — 6C4	R.F. Oscillator	V-1
3 — 6J6	Sync. amplifier	V-11
	Horizontal Sweep Oscillator	V-12
	Vertical Sweep Oscillator	V-13

* NOTE: The 3KP1 has a green screen. The equivalent tube with a white screen, when available, will be 3KP4.



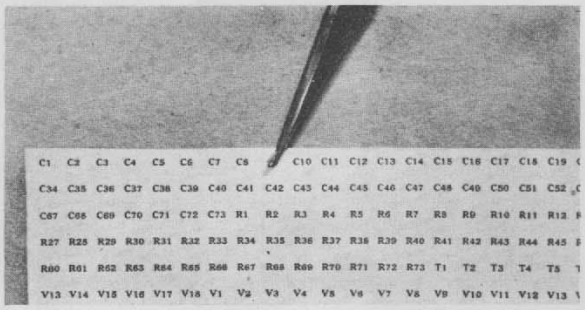
Core Adjustment and Tube Locations

CHAPTER V

IDENTIFYING PARTS

All the parts should be accumulated and checked against the parts list. They should then be laid out on a suitable table area in groups, with the paper capacitors sorted from the ceramics, the micas and the electrolytics and the several sizes of resistors sorted according to their wattage values.

If available, adhesive type identification symbols can be affixed to the various parts as indicated in the parts list, the capacitor identification list and the resistor identification list. When adhesive symbols are not available, hand lettering will, of course, suffice.



Adhesive Symbols—Easily Handled with Tweezers

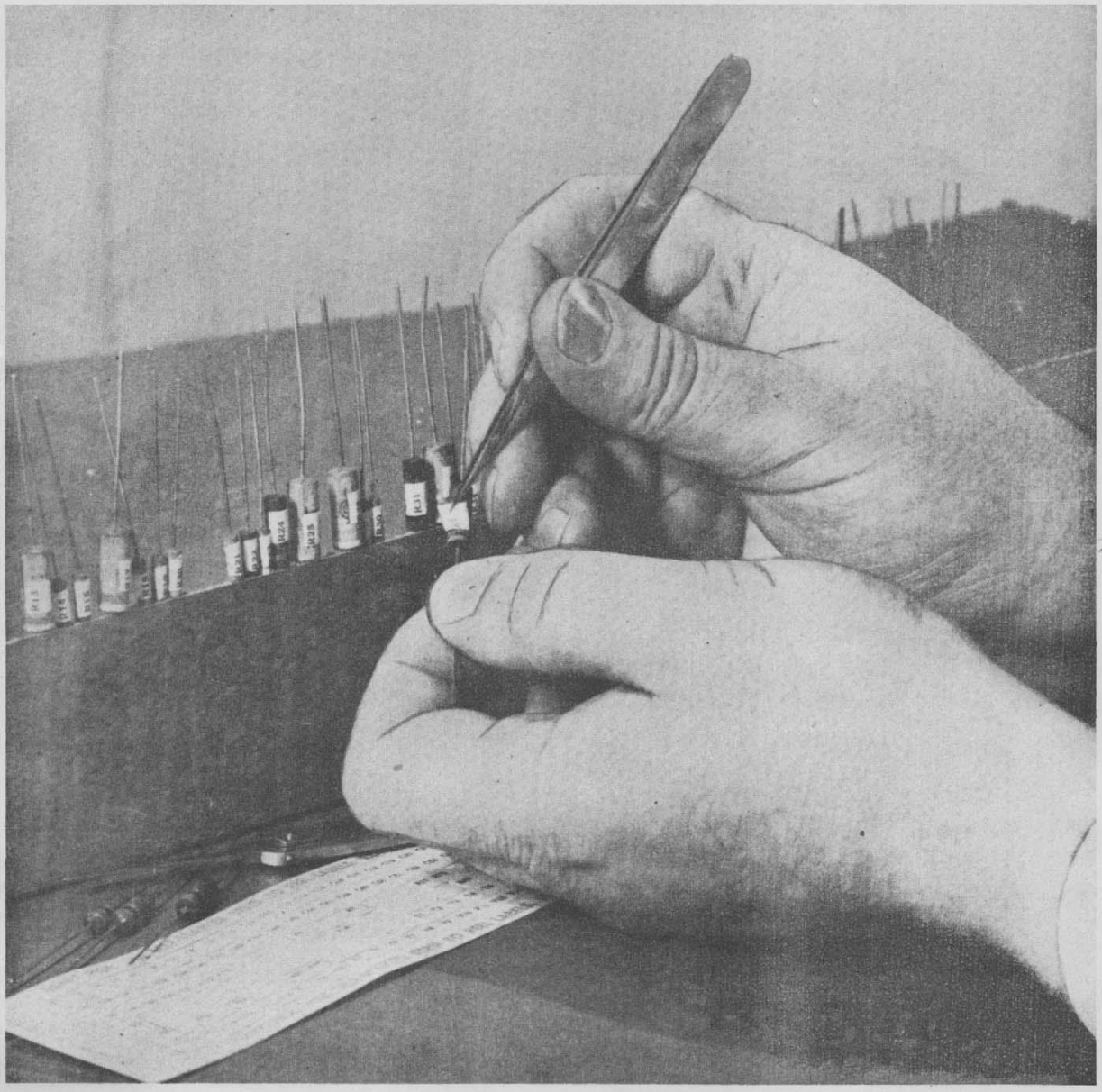
The markings used for identification, it will be noted, are the same as those used on the schematic diagram. This makes possible either construction from the diagram or an assembly based on production line procedure in which each operation is processed through the use of previously identified parts.

Capacitors can easily be identified by the markings on them which are shown in microfarads (mfd.) or "cap" for capacity and in d-c working volts. The ceramic type may either have stamped lettering to show values in micro-microfarads (mmf.) or may use the less common color coding. Since there are 29 of the 1000 mmf. ceramics all alike, they need not necessarily be marked before being wired in place.

The resistors, after being separated according to wattage rating, should then be sub-divided according to the first significant color band, which is the one farthest away from the silver or gold tolerance band. Next the respectively colored resistor should be laid aside of that line on the resistor identification list which shows the proper marking for it. When all are accounted for, the "R" numbers can be affixed and the resistors arranged numerically by racking them in a strip of corrugated board. This will facilitate locating any resistor quickly during construction and it will be found to be most convenient, even to experienced constructors.

Capacitor Identification

3-12 mmfd. variable	C-13	
4.7 mmfd. ceramic	C-9	
6.8 mmfd. ceramic	C-4, 8	
8.2 mmfd. ceramic	C-10	
10 mmfd. ceramic	C-3	
15 mmfd. ceramic	C-2	
56 mmfd. ceramic	C-14	
500 mmfd. ceramic	C-52	
820 mmfd. mica (square)	C-56	(color marked grey-red-black-silver-black)
1000 mmfd. ceramic	C-15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 39, 40, 41, 42, 45, 46, 47, 48, 53, 58, 59	
1500 mmfd. mica (square)	C-62	(color marked brown-green-black-silver-brown)



Attaching Identifying Symbol to a Resistor

.002	mfd. oil tubular 1600 v.	C-38
.005	mfd. paper tubular 600 v.	C-60, 61, 70, 73
.01	mfd. paper tubular 600 v.	C-12, 35, 55, 57, 72
.05	mfd. paper tubular 400 v.	C-54, 65, 71
.1	mfd. oil tubular 1600 v.	C-66, 67
.1	mfd. paper tubular 400 v.	C-34, 64, 69
.25	mfd. paper tubular 400 v.	C-63, 68
25.	mfd. electrolytic 25 v.	C-36
4x20	mfd. electrolytic 450 v.	C-37A, B, C, D