PLANT REQUIREMENTS FOR MANUFACTURE OF RADIOS

TECHNICAL AIDS BRANCH
INTERNATIONAL COOPERATION ADMINISTRATION
Washington, D. C.

FOREWORD

This brochure is one of a series of reports resulting from overseas technical inquiries on factory or commercial establishments, operation, management, and engineering. The report is designed to provide only a general picture of the factors that must be considered in establishing and operating a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice in order to meet specific local conditions.

Mention of the name of any firm, product, or process in this report is not to be considered a recommendation or an endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

Industrial reports prepared for ICA under special contract are customarily reviewed and edited before publication. This report, however, like other technical inquiry replies, has not been reviewed; it is the sole responsibility of the firm that prepared the report.

This brochure was prepared in September 1957 by the George H. Andrews Engineering Associates, Inc., Washington, D. C.

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For further information and assistance, contact should be made with the local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

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Technical information, as well as review of this brochure was provided by

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RADIOS

INTRODUCTION

The small radio manufacturing plant described in this brochure is designed to produce radio receiving sets where the demand for this product exists and where such a local operation would be practicable. It has several particular characteristics of special merit in connection with programs for economic development. Some of these afford advantages which will become apparent in the more detailed presentation in the following pages of this brochure. The most important ones briefly stated are as follows:

Small investment of fixed capital.
Range of choice as to volume of operation to be undertaken.
The rapidity with which the project may be changed.
The ease with which operations may be expanded in many different directions.
The speed with which unskilled workers can become proficient even though they do not have a technical education.
The social and cultural value of the product, which should lead to its wide distribution.
The ease with which such a product can be maintained.
The high proportion of production cost which goes to employment of local people.

There are various designs of radio receiving sets. The radio receiving set on which these estimates of production and cost are made, is simple, sturdy and of excellent quality.

The plant and facilities are, in fact, capable of making more elaborate models and other electronic equipment of many kinds where the nature of the market makes production of such other models and equipment desirable.

This radio manufacturing plant is designed as a prototype, affording a pattern to be followed where the conditions which have been assumed are matched. It is intended, however, that these assumptions should be modified to conform to other conditions which may obtain where actual initiation of such an industry is contemplated. The appropriate changes in the assumptions should also be made if it is intended to start the radio manufacturing plant on a smaller scale, or if any other important changes are planned. To emphasize these changes, spaces have been provided, in the text, for new estimates to conform to the requirements that are different.

GENERAL ASSUMPTIONS

In order to make realistic estimates, certain assumptions must be made. These are:

1. That a market analysis has proved that annual sales of at least 25,000 radio receivers are possible.

2. That all costs, such as those for building, equipment, materials and supplies, are based on current costs in the United States.

3. That the operating costs, including labor used, are taken from actual operating experience in the United States.

4. It is also assumed that adequate transportation facilities are available for the importation of materials and parts and for the distribution of the finished product.

5. Adequate power and water are available at the plant site.

6. All estimates are based on one 8-hour work shift per day, 5 days per week, or 40 hours per week.

7. Peak production is not likely to be attained until the whole organization is thoroughly trained. It is estimated that this training will require one month.

8. Most of the materials and parts will not be available locally and must be imported.

9. The following items cannot be estimated realistically:

   A. Land value.
   B. Freight, in and out.
   C. Distribution and sales cost.
   D. Taxes, interest, insurance and other burdens.

   While general estimates will be made of each of these items for the purpose of completing cost estimates, adjustments should be made in accordance with actual local costs. In fact, all costs contained in this brochure should be adjusted to conform to local conditions.

PRODUCT SPECIFICATIONS

The small radio manufacturing plant described in this brochure is designed to produce a sturdy, good quality radio receiver, of a type comparable to those made and widely used in the United States. The radio receiver on which the estimates are based is a five-tube table model.

The basic principles upon which a radio receiving set is built are quite simple. Electromagnetic waves, usually called radio waves when spoken of in this connection, can be picked up by an improvised antenna of the simplest form. All that is needed to convert the radio signal into sound is a device to provide a path which will separate the audio frequencies from the carrier and which will provide another unit to convert the resulting waves of audio frequency into sound. In the earliest forms of receivers which had any popular use, the transition from radio waves to sound was accomplished with a simple crystal set that a child could build. These sets, however, had limited value because they provided no amplification and could not be sure to pick up waves from sending stations which were distant or weak, nor could they separate the signal of one sending station from that of another with nearly the same characteristics. The parts which the present project adds to those first types, or substitutes for less satisfactory early parts, provide power supply, amplification and selection. The basic principles are, however, still the same.

The parts which are assembled in a modern radio factory, such as the proposed radio manufacturing plant, to make a modern commercial radio receiving set, are made in various factories, each specializing in a particular part of such work. It would be impracticable to incorporate all the machinery for making these parts in one place, particularly in a small radio manufacturing plant, because the capital investment would be too great in proportion to the volume of the final product and most of the equipment would be used only a small part of the time.

The circuit of the radio receiver proposed for construction in this prototype factory is a superheterodyne. A superheterodyne receiver has an antenna that picks up a radio signal which passes through a radio frequency tuning system, and then through a mixer tube where it is combined with the signal from a local oscillator which is one of the component parts. The output is an intermediate frequency signal which has low carrier frequency and all the modulation present in the original signal. This changed signal, when put through an intermediate frequency amplifier, a detector, an audio amplifier and speaker, has great advantages. Because of its sensitivity and selectivity, this circuit is commonly used in modern receivers in the United States and is recommended for the receiver to be manufactured in the radio manufacturing plant described in this brochure. There are several ways in which the wiring and the various parts may be arranged.

The most of the description herein is based on using what is known as the Armstrong type superheterodyne circuit. There are, however, other circuits, each of which has certain advantages. This radio is enclosed in a bakelite cabinet. Terne plate is used for the chassis to avoid rust which would attack untreated steel in damp climates; also to avoid changes which extremes of moisture content cause in wood. A high efficiency loop antenna and high gain intermediate frequency transformers are also specified. The specified frequency range is 550 kilocycles to 1500 kilocycles. The power supply is assumed to be 110 volts, either alternating or direct current, where the receiver is to be used.

The completed radio is about 5 inches by 5 inches by 9 inches and its weight is about 5 pounds.

It should be noted that special inhibiting treatment should be given all sets which are to be used in places where damaging fungus growth is likely to occur. This requires spray equipment and a booth, which are not included in this design. The added cost, including material, labor and overhead is 25 cents per set.

As an illustration of the advantage of buying instead of manufacturing certain parts, consideration may be given to the chassis. This may be made of wood, metal or a synthetic composition. A prefabricated metal chassis is recommended. Metal chassis provides electrical shielding. This is important. If wood is used, the chassis will be subject to changes of shape or condition, which would have a bad effect on the way the tubes and other parts would fit into the ensemble. Metal overcomes this objection, but, if manufactured in the proposed plant, the expense would be increased because of the cost of fabrication. The chassis must have many holes of different sizes and different shapes. To make these holes by punching one at a time, is very expensive and there is the danger of error. This can be overcome if the holes are all punched in one operation. The cost of a press to do this, not including dies, would be about $20,000 and it would be busy less than one half of one percent of the time. The operator would have to be given other work and valuable floor space would be wasted.

These and other considerations make it economical for a small plant to purchase metal chassis, ready for use.

A similar situation applies to the plastic cabinet. Although it might be made in the proposed plant, production equipment would cost about $50,000 and it would actually be cheaper to buy the cabinet from another local plant or have it imported. The alternative, of possible use of wood, should also be examined if unusual restrictions to importing plastics are imposed.

Some countries have restrictions on importation of items comparable to the metal chassis or the plastic cabinet. These restrictions are generally adopted to protect local industries. Where such conditions obtain, it will be advisable to buy from the local industry rather than to establish a new, competing industry as part of the radio manufacturing plant.

On the other hand, if there is a potential market for other metal products comparable to the chassis and for plastic items comparable to the cabinet and if that market is great enough to keep these units busy on productive work, it would be profitable to install them. Such installation probably would, however, be independent of the small radio manufacturing plant.

When expansion of the small radio manufacturing plant becomes desirable, it will doubtless be most practicable to manufacture additional electronic products, and products of a similar nature. Such expansion would use the same type of personnel as are employed by the small radio manufacturing plant and would require also relatively small amounts of fixed capital.

CIRCUITS

There are several ways of assembling the various parts of standard manufacture to make a superheterodyne receiver. The one described briefly above and illustrated in the drawings is known as the Armstrong type. There are variations known as the Colpitts, and the Hartley, and others. Circuits may be printed and patented. Advantages are claimed for each. It should be noted that use of any patented circuit form may require permission, particularly if the product is to be sold in America. The general features involved in various hook-ups may be quite similar in a number of models. The one described, however, is used by many, and this particular arrangement is used by Radio Kits, Incorporated, in the preparation of their Arkay Kits. Their description is followed here by permission of Mr. Irving Becker, President of that Company. The ease with which this superheterodyne circuit can be built is a feature of the plan that was worked out in practice by Mr. Becker in the successful operation of small radio plants in Mexico, using Mexican labor and with facilities much simpler and much more limited than those described herein. Assembly was accomplished at the rate of one radio per man per hour.

Another arrangement, slightly different, is shown in "Electronics Made Easy". Mr. Lother Stern, the author of that book, describes a 5-tube receiver and gives a list of material required to build it.

Other satisfactory circuits could be devised. The cost would not differ greatly from the ones shown in this brochure.

MANUFACTURING OPERATIONS

RECEIVING

Inspection and testing of parts and materials as they are received is very important. Since it has to be done by persons familiar with requirements stipulated for all the parts and acquainted with physical and electrical testing, the operation is included as part of the manufacturing. All the items will be inspected as to general appearance. Ten percent will be given physical spot check and ten percent will be given an electrical check.

MACHINE SHOP

A very small shop with bench type machines has been included as part of the proposed small radio manufacturing plant. It is not intended that all parts will be routed through the machine shop. Some parts will be received complete, ready for the assembly line. The facilities will be needed for regular plant and equipment maintenance as well as for use in connection with regular products. They will also be needed for special jobs, which will be part of the activity of this plant, although not included in the operating figures.

Elsewhere in this brochure, expansion of production is recommended, when the initial operation has become efficient. This machine shop equipment will facilitate that expansion. Two machines are included in the machine shop for regular use from the beginning of the plant operations. These are the riveting or eyeletting machines that fasten the tube sockets to the chassis. This is the first step in the sub-assembly. From the eyeletting or rivetting machines, the work in process moves to the second step of sub-assembly.

Meanwhile, hook-up wires are cut to length, stripped on both ends and otherwise prepared in the machine shop, using jigs to bend them to the required shape. Three colors of wires are used; green coated wires for the power circuit, red coated wires for the second stage, and black coated wires for the third, or final stage. These wires in lots which will be specified, are placed at the proper points on the assembly line.

STOCK ROOM

Lugs, wires and other appropriate parts and supplies are also moved from stock to sub-assembly; and to the appropriate places on the assembly line.

SUB-ASSEMBLY

In sub-assembly all mechanical assembly is done in three stages:

Stage 1. All tube sockets are mounted on the chassis, using eyeletting machine or rivetting machine.

Stage 2. Dial drive, volume control, intermediate frequency transformer, and variable condenser are mounted. Dial cord is strung. Dial face and pointer are mounted.

Stage 3. Speaker is mounted. Cardboard is inserted to protect speaker. Output transformer and line cord grommet are mounted and the line cord is knotted.

The receiver is then ready for main assembly operator number one.

MAIN ASSEMBLY

This manufacturing step includes wiring and soldering, inspecting and testing, repairing, adjusting, packing or boxing, and storing. The wiring and soldering is divided into three steps, as follows:

MAIN ASSEMBLY, STEP 1

Power circuit hook-up wires (green wires) are connected. There are 12 hook-ups. When this wiring is completed, the tubes are placed in their sockets, the dial light is placed in its socket. When the circuit has been checked, the line cord is plugged into the outlet, the switch on the volume control turned to the "on" position. All the tubes and the pilot light will light up if the assembly is correct.

MAIN ASSEMBLY, STEP 2

Rectifier and audio-amplifier circuits (red wires) are connected. There are 21 hook-ups. Step 2 is followed by the first inspection. Insulated sleeving, spaghetti tubing, is then placed over the leads of condensers and resistors.

MAIN ASSEMBLY, STEP 3

Complete the wiring. These hook-ups (black wires) require 21 operations to tie in intermediate frequency transformers, resistors, condensers, ground lugs and loop antenna. When this step has been completed, it is inspected.

FINAL INSPECTION

The radio receivers then are moved off the assembly line into an adjacent room where they can be given final inspection and adjustment, or correction and airtest. The airtest is a final check over the complete tuning range. Performance is checked by a person familiar with good performance over that range.

BOXING, PACKING, SEALING

The finished radios are placed in air cushioned cartons. These provide full bracing all around the receiver with an inch of space separating the radio from the wall of the carton on every side, as well as top and bottom. The cartons are sealed with paper strips.

FLEXIBLE OPERATION

Assembly, as well as sub-assembly, is set up so each person in the line has a limited part of the work to do, thus requiring the least amount of detail to learn and remember. Each person on assembly works opposite another person who is doing exactly the same operation. Inefficient operation can thus be quickly discovered and corrected. It is possible to change the division of work between stages. In fact, the whole pattern can be changed, if experience discloses a better system. The relationships between steps are not so rigid as they would be if paced by the operation of some large machines.

CREW TRANSFER

The positions shown for various workers are not rigidly fixed. The transfer of persons putting out stock parts and supplies from the beginning of the line in the morning to the final steps later in the day, and to repair, is a practical way to keep an even distribution of the work.

Persons employed on inspection of goods being received are used on final inspection and repair, and on sub-assembly, depending on the need at each place.

JIGS

Full use is made of jigs on which the work in progress is supported while parts and wires are being placed and while soldering is being done. The work is fitted at the angle which, experience has shown, enables the operator to produce best results with the greatest ease of operation.

PRODUCTION CAPACITY

The capacity of this plant is 100 five-tube radio receivers per 8-hour working day. Production capacity can be increased by working longer hours, or by using extra shifts as shown below:

Shifts per day	Hours per shift	Units per day
1	8	100
1	10	125
2	8	200
2	10	250
3	8	200

Since the capacity of equipment is not a factor in any reasonable increase in production, that increase can be accomplished by adding personnel, providing appropriate hand tools are available. Additional working capital will probably be required to take care of the increased inventory. No additional equipment or increase in fixed capital will be required from a production of 300 units per day, if the plant is operated in accordance with the above hours per shift and shifts per day.

PLANT SITE

The plant should be located where it can be reached by vehicles and pedestrians without great difficulty and where electric power service can be had. The facilities required for the small radio plant described in this brochure will not justify the purchase of a large site nor one that is costly because of its location. The requirements for later expansion can be met by moving to a new location when necessary. The estimated cost of the required land is $1,000.

BUILDING

The manufacturing process is one which can be rearranged to fit suitable building space already available. It would require less capital and may be desirable for other reasons to rent one or more buildings and postpone the construction of a building until the nature of the established manufacturing plant can be more definitely fixed.

Whether rented, purchased, or built, the proposed small radio plant, described in this brochure, including storage and all other activities, can be housed in a building having about 4,000 square feet of floor space. If the potential sales are less than 100 radios per day, it will be physically possible to build fewer radios in a smaller building, but new estimates must be made as the costs will not all be reduced in proportion.

The cost of a suitable structure, including heating, plumbing and other building equipment, if purchased or built, is estimated at $24,000.

POWER

A dependable supply of electric power is required and it is assumed that this will be available. Current for lighting, for testing and for a few small motors would be all that is needed. The annual cost is estimated at not more than $1,000.

WATER

Water is needed for drinking, for sanitary purposes and for fire protection. The total annual cost should not exceed $40.

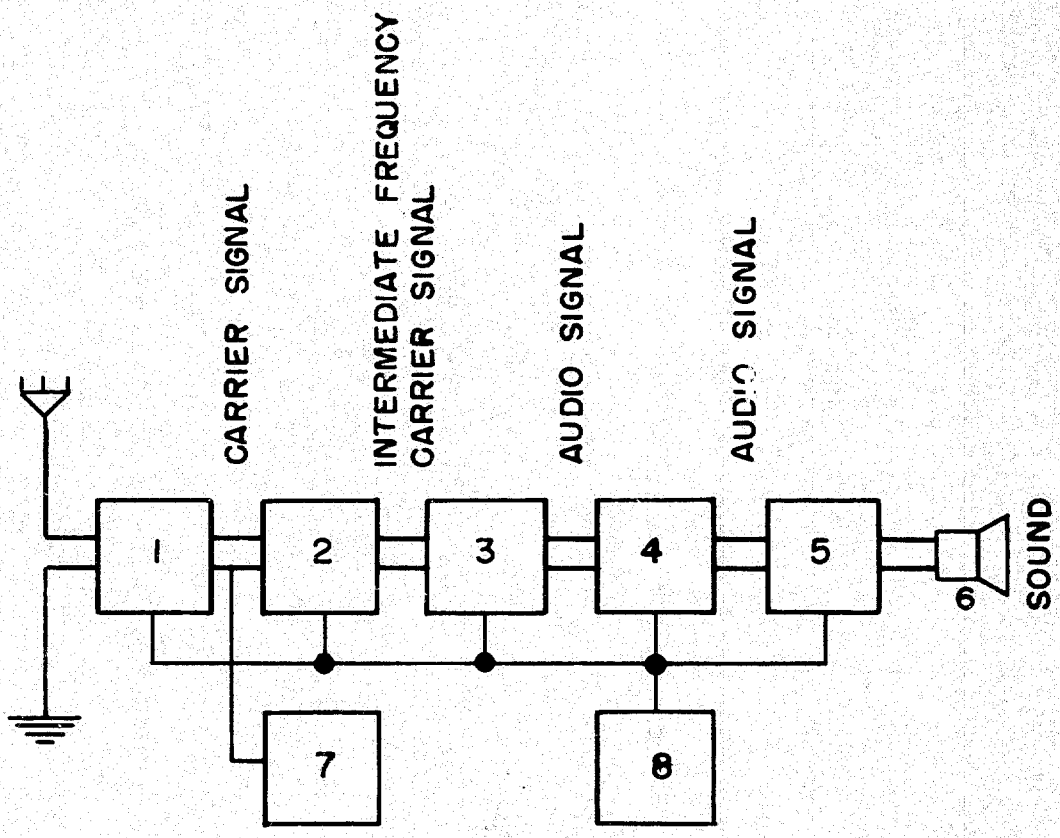
FUEL

It is estimated that fuel for heating purposes will cost, annually, not more than $200.

TRUCK

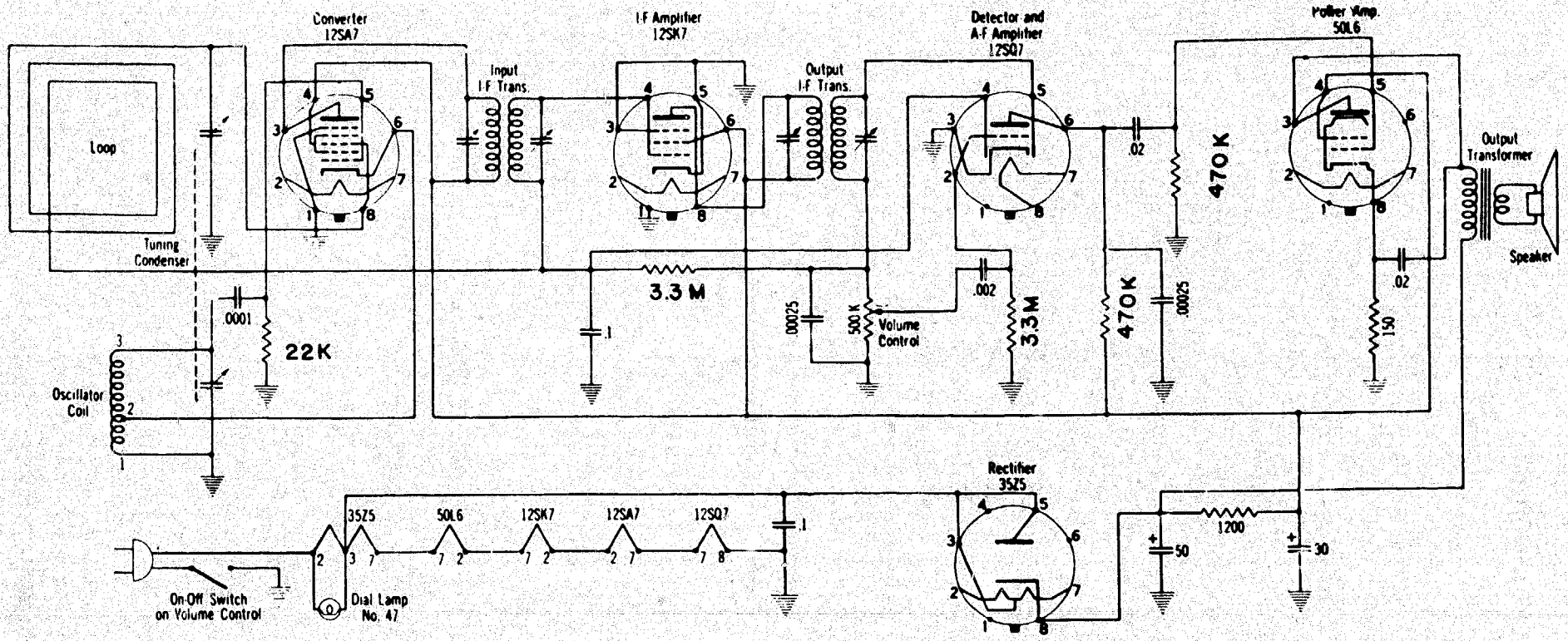
Pick-up and delivery will not require full time use of a truck. Truck service can be supplied by rental, the cost of which, yearly, will probably be less than the cost of owning, maintaining, and operating a truck. This would also reduce the amount of initial capital required. For the purposes of this brochure, however, it is assumed that a truck will be purchased and used. The estimated cost is $2,400.

SUPER HETERODYNE
RADIO RECEIVER
BLOCK DIAGRAM



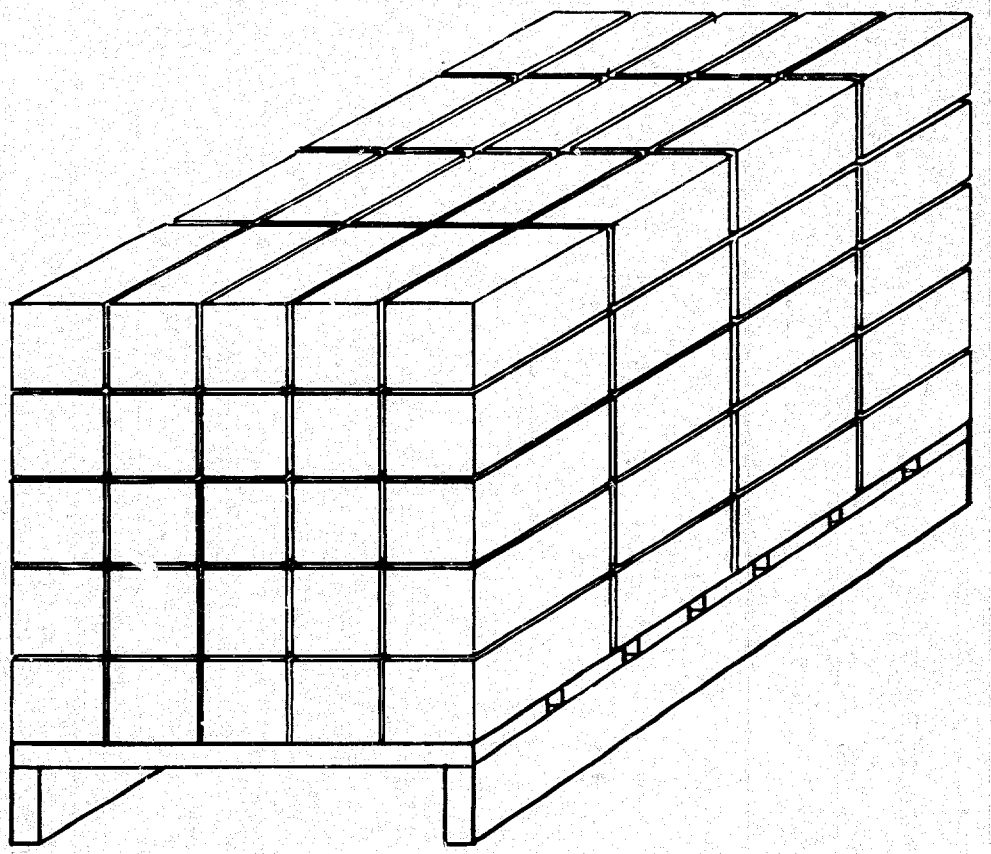
1. RADIO FREQUENCY TUNER.
2. CONVERTER, MIXER, FIRST DETECTOR.
3. INTERMEDIATE FREQUENCY AMPLIFIER.
4. SECOND DETECTOR.
5. AUDIO FREQUENCY AMPLIFIER.
6. SPEAKER.
7. OSCILLATOR
8. POWER SUPPLY.

SUPERHETERODYNE BLOCK DIAGRAM


Converter
12SA7
I-F Amplifier
12SK7
Detector and
A-F Amplifier
12SQ7
Power Amp.
50L6
Input
I-F Trans.
Output
I-F Trans.
Loop
Tuning
Condenser
Oscillator
Coil
.0001
22K
3.3 M
.1
.0025
500 K
Volume
Control
.002
3.3M
.02
470K
470K
.0025
.02
150
Output
Transformer
Speaker
Rectifier
35Z5
1200
50
30
35Z5
50L6
12SK7
12SA7
12SQ7
.1
On-Off Switch
on Volume Control
Dial Lamp
No. 47

SCHEMATIC

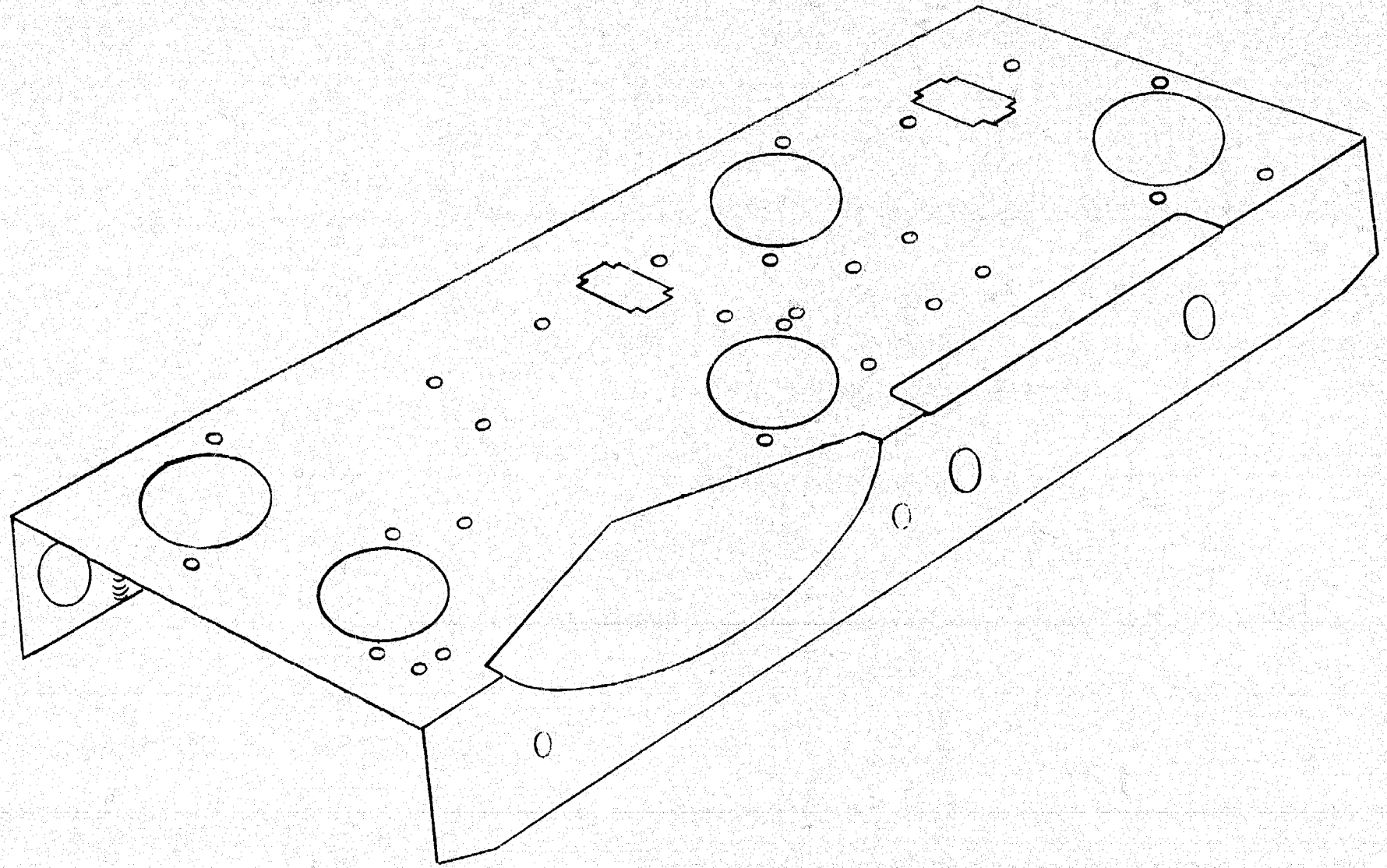
SKID STORAGE — FINISHED CARTONS



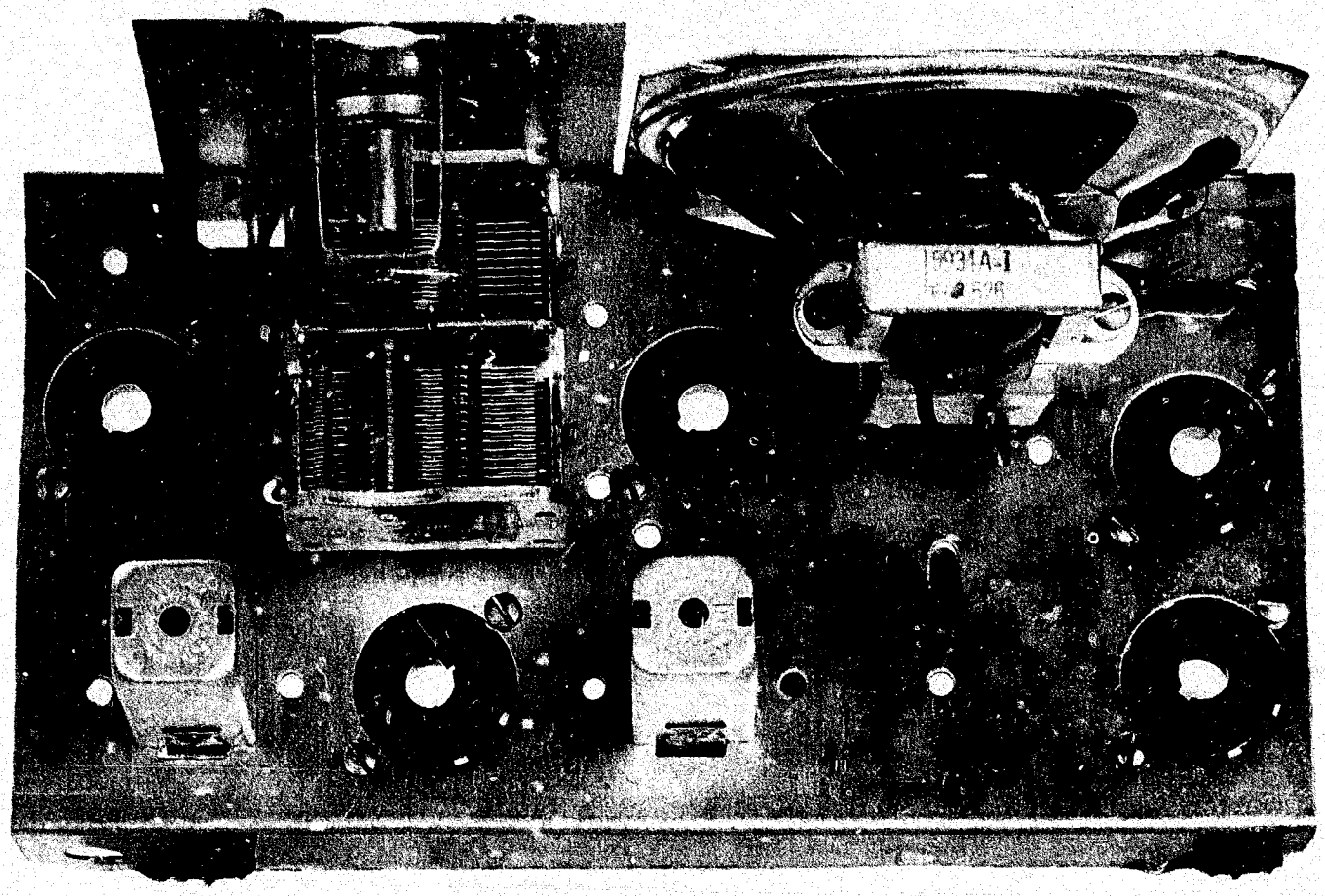
DRAWING SHOWING SKID CARRYING ONE DAYS PRODUCTION, 100 CARTONS, EACH APPROXIMATELY 7 INCHES BY 7 INCHES BY 12 INCHES.

SKIDS PROVIDE A SATISFACTORY WAY OF STORAGE AND HANDLING MANY OF THE CARTONS AND SUPPLIES.

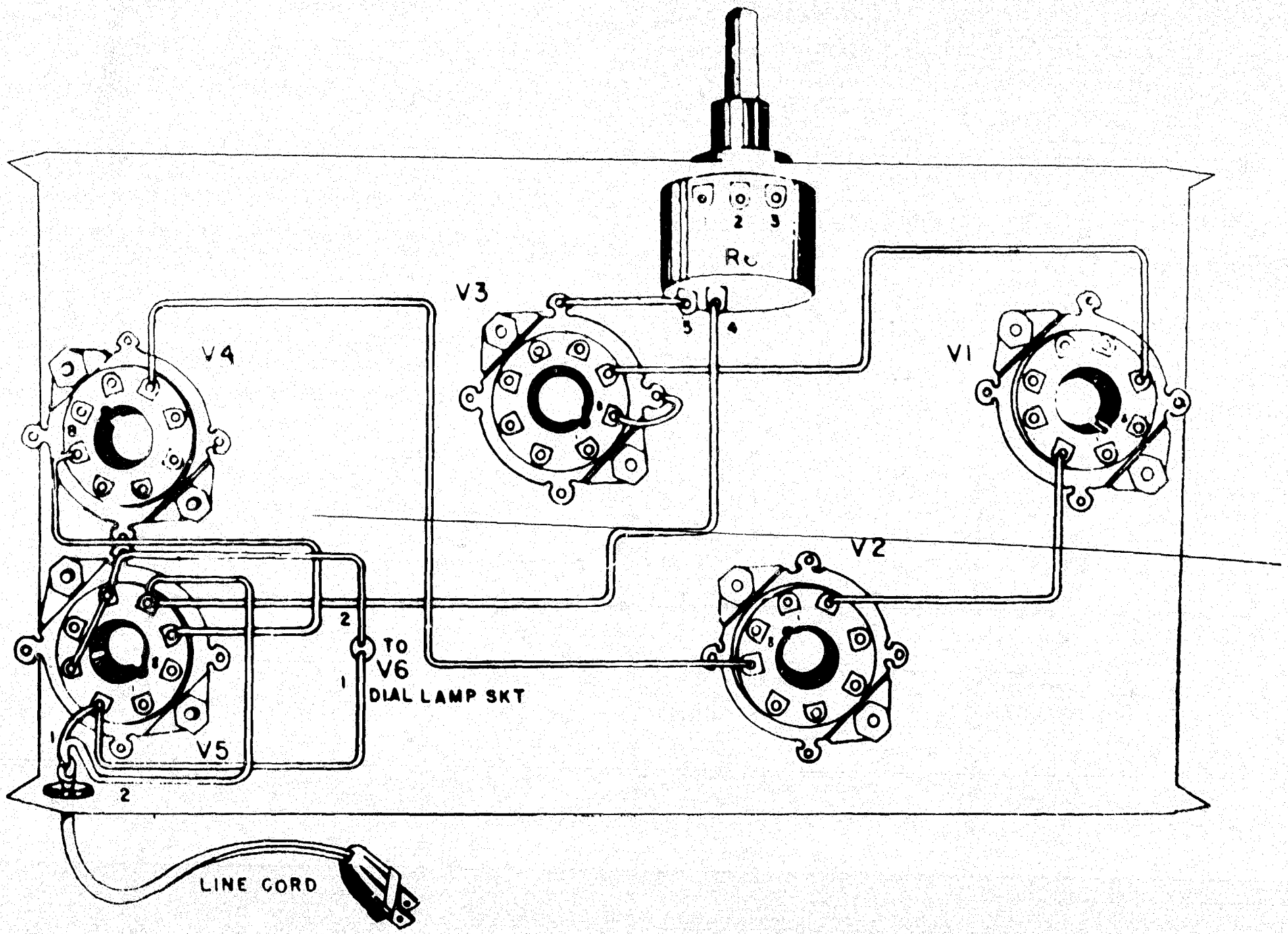
ONE DAY'S PRODUCTION



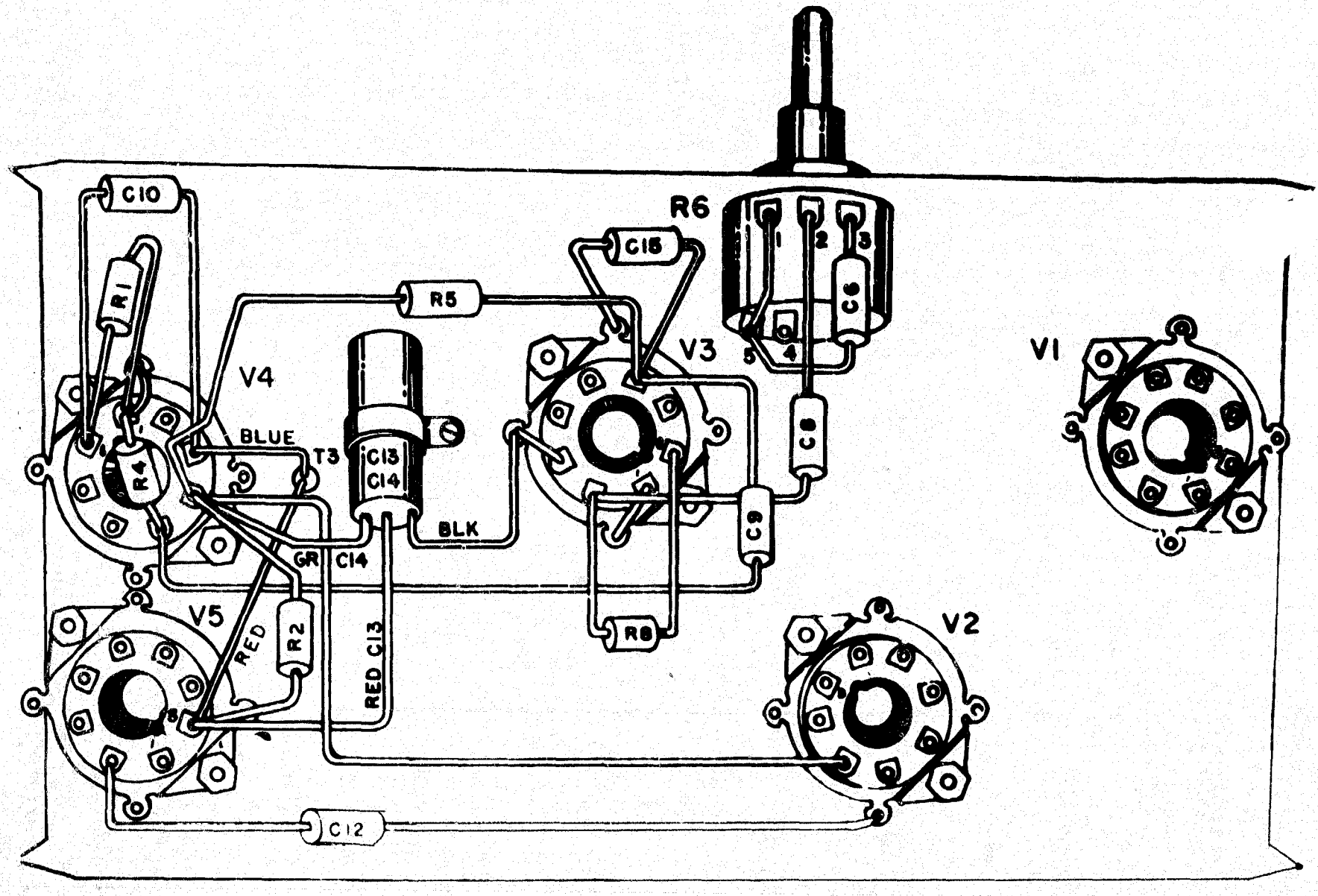
CHASSIS, DRAWING



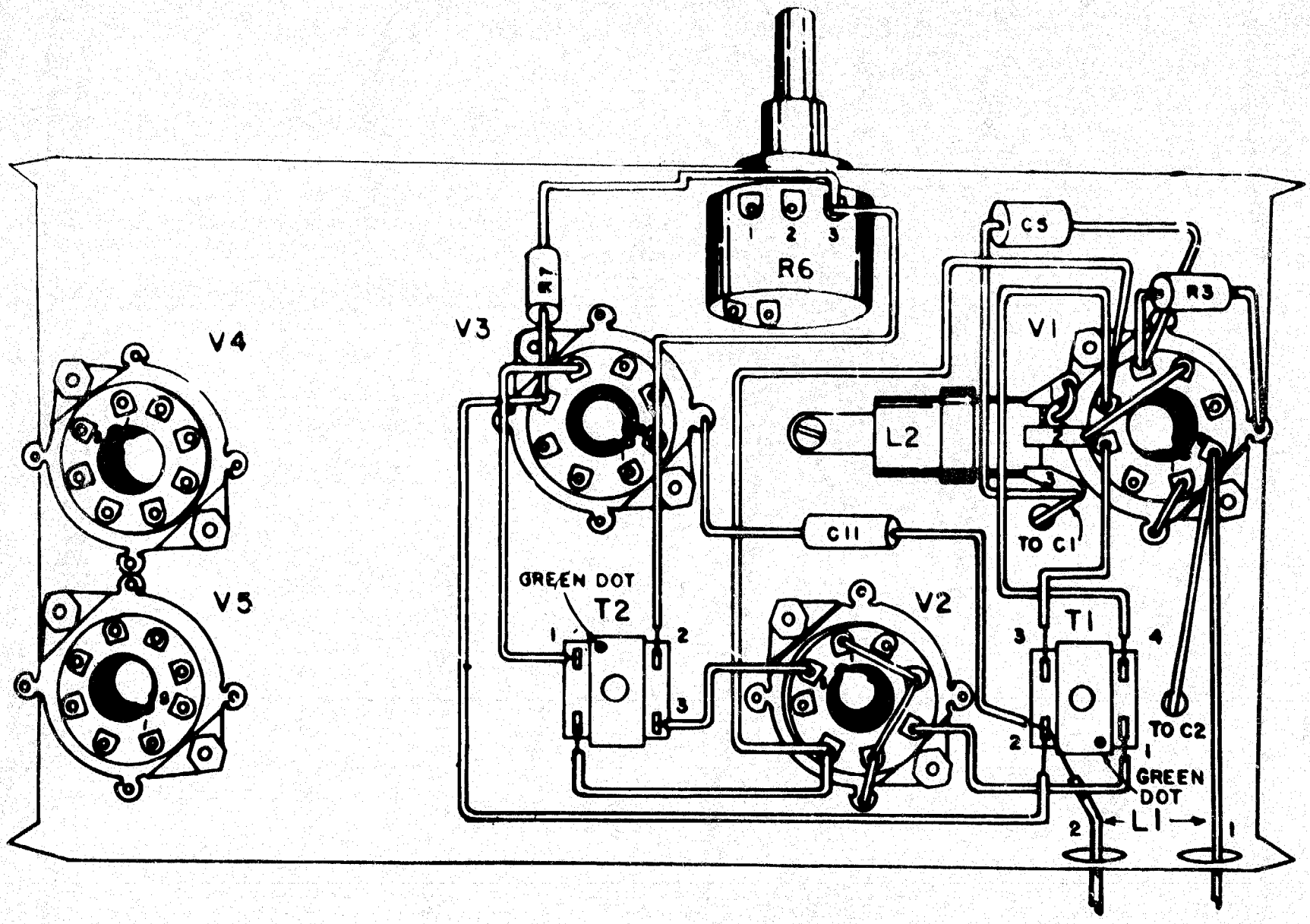
CHASSIS, WITH PARTS MOUNTED



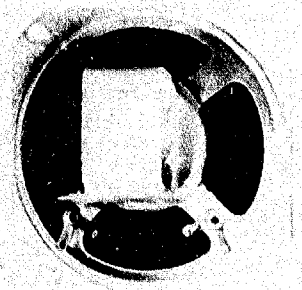
FIRST ASSEMBLY - DIAGRAM



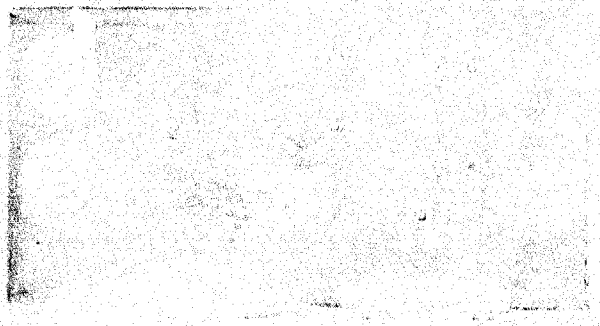
SECOND ASSEMBLY - DIAGRAM



THIRD ASSEMBLY - DIAGRAM

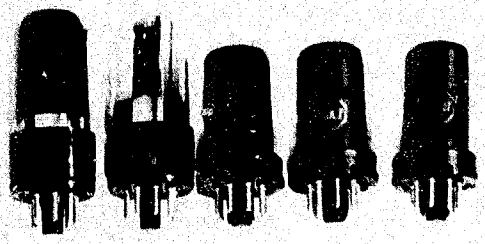


LOUDSPEAKER

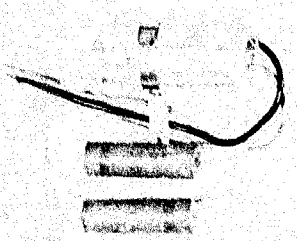


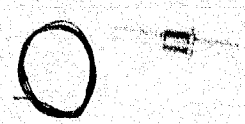
RECEIVER CHASSIS

DIAL-LIGHT ASSEMBLY



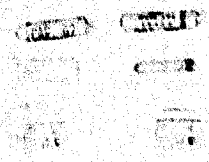
VACUUM TUBES





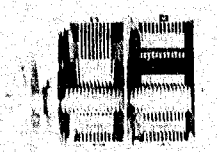
DIAL-DRIVE ASSEMBLY

VACUUM-TUBE SOCKETS

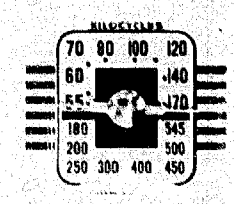


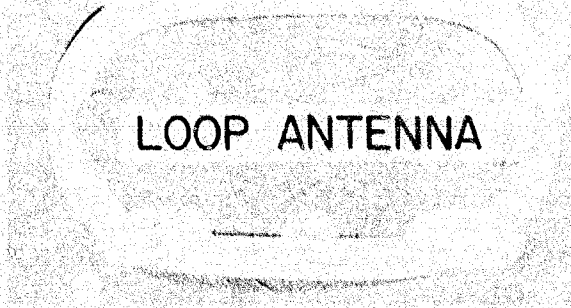
FIXED CONDENSERS

I-F TRANSFORMERS



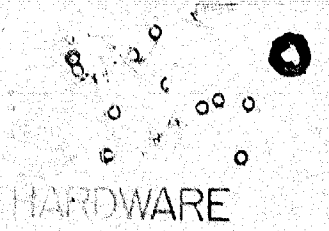
TUNING CONDENSER





LOOP ANTENNA

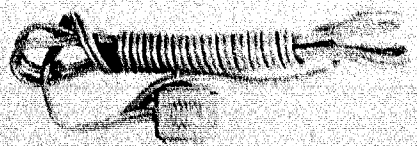
VOLUME CONTROL AND LINE SWITCH



HARDWARE

DIAL PLATE

KNOBS



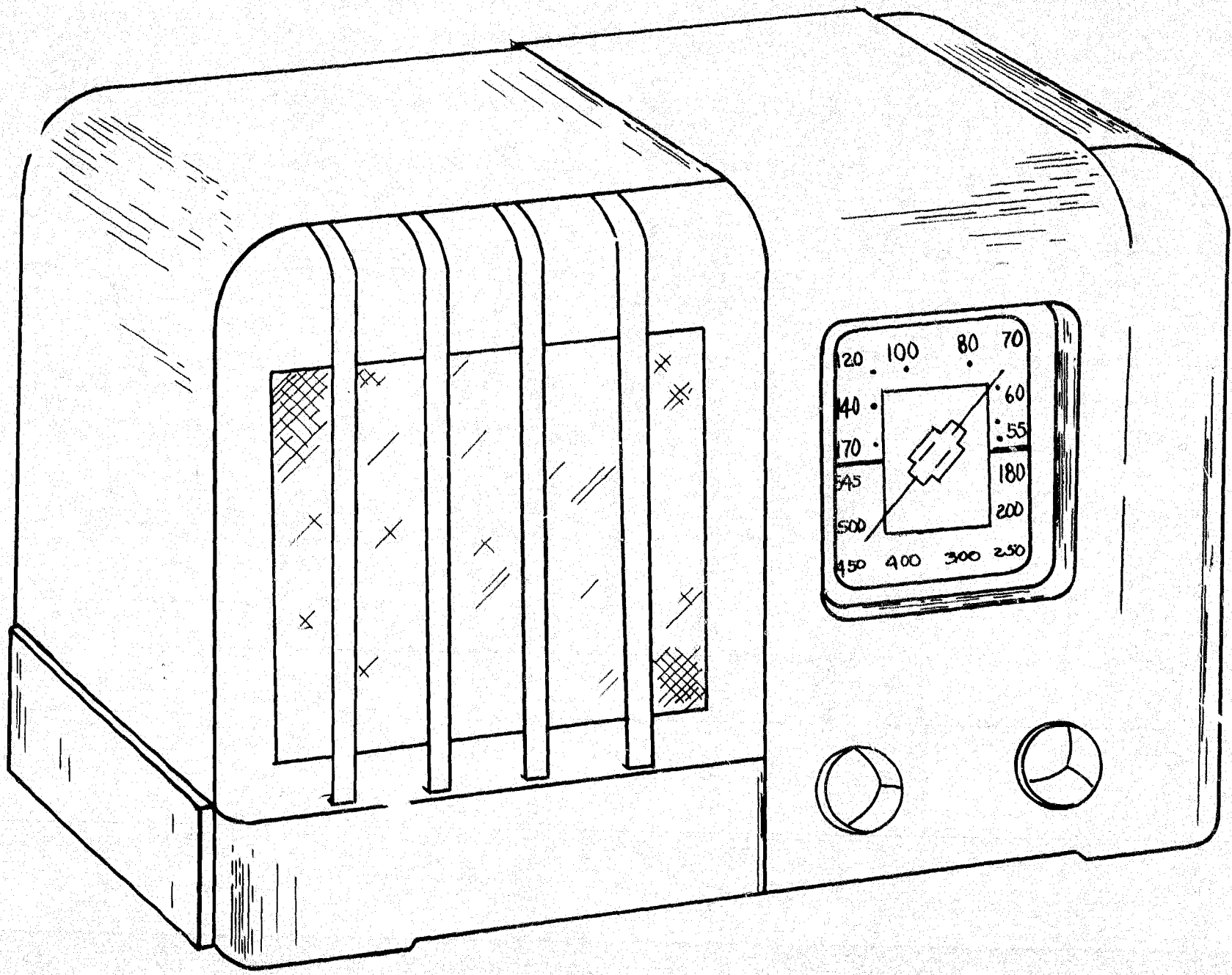
LINE CORD

FIXED RESISTORS

OSCILLATOR COIL

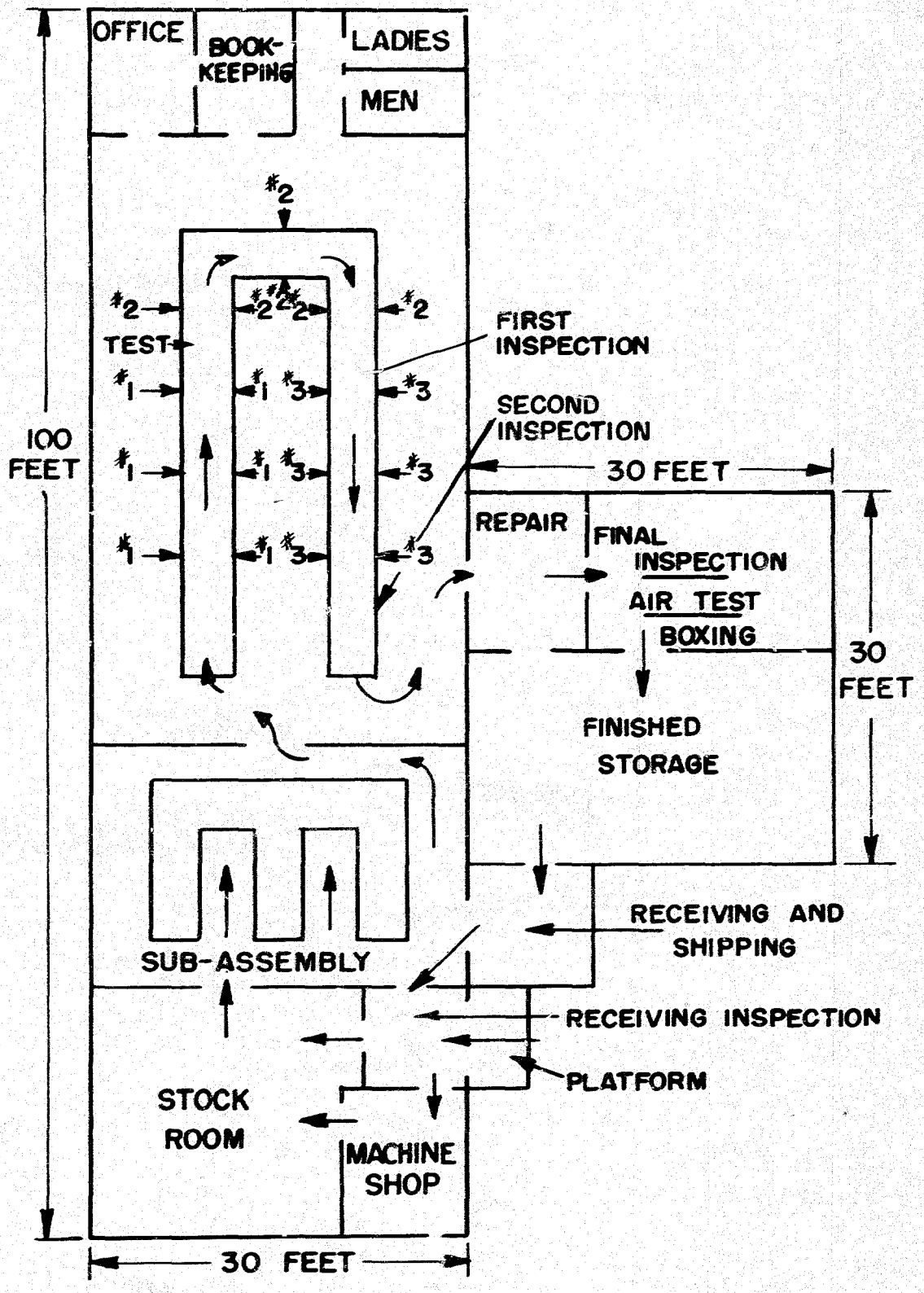
OUTPUT TRANSFORMER

VIEW OF ASSEMBLED PARTS



VIEW OF RECEIVER

PLANT LAYOUT



EQUIPMENT

Item	Estimated Cost	Actual Cost
Two belt conveyors, complete, with reducing gears	$ 2,050	$_____
Two hydraulic hand lift trucks	1,200	_____
100 skids	400	_____
Electric motors, wiring, switches	800	_____
Testing instruments and facilities	1,500	_____
Fixtures, forms, dies, jigs	1,000	_____
Vices, bench tools	300	_____
Soldering equipment	400	_____
Coil winder, drills, wire cutting and wire stripping tools	690	_____
Wood working tools and equipment	700	_____
Three eyelet machines, or rivetters at $300 each	900	_____
Bench grinder	200	_____
Hack saw	300	_____
Punch press	505	_____
Horizontal band saw	375	_____
Bench drill press	170	_____
Electric drill	94	_____
Small bender	275	_____
Hand tools	141	_____
TOTAL ESTIMATED COST OF EQUIPMENT	$ 12,000	$_____

Equipment includes some items for custom work and for special work, not part of regular production. It is certain that some such work will be undertaken and, since these are low cost items, of general utility, they have been included in the estimated equipment cost. No such operations, however, are included in estimating the business.

FLOW SHEET

PARTS AND SUPPLIES

A. Incoming inspection to stock room.
B. Stock room to shop.
Shop operation
B 1. Rivet receptacles to chassis
B 2. Mount other parts
B 3. Cut, strip and bend wires
B 4. Return to stock room
C. Stock room to sub-assembly.
Sub-assembly operations
Through stage 1, stage 2, stage 3
D. Sub-assembly stage 3 to assembly.
E. Wires to assembly.
Green wires to step 1, red wires to step 2, black wires to step 3
F. Soldering. Step 1, green wires.
G. Test power circuit.
H. Soldering. Step 2, red wires.
I. Test audio circuit.
J. Soldering. Step 3, black wires.
K. Final inspection and air testing (in repair room).
L. Repair and return to final inspection.
M. To carton.
N. To finished stock.
O. Shipping.

MATERIALS HANDLING

Assembly line handled on belt-conveyor.

Skids are used for the movement of materials throughout the plant. Skids are raised platforms, which are lifted from the floor and moved about with hydraulic hand-lift trucks. One skid will easily carry finished cartons for one day's production, 100 cartons. Skids can be used for storage of stock and thus reduce handling.

FIXED ASSETS

One great advantage which the small radio manufacturing plant has is that it requires little, or no, capital investment in fixed assets.

This makes it possible to start operations with a relatively small fixed investment.

It is possible, in almost any community, to find a building which, with a minimum of alterations, can be made to serve the purposes of a small radio manufacturing business. Use may be made of unoccupied residences. Suitable space may be found in an industrial building where other activities are carried on, provided there is no interference either by personnel or by unsuitable physical conditions, such as excessive vibration or dust and dirt. Hired service may be depended upon instead of a purchased truck. The combined weight of all the radios proposed as this plant's initial daily production would be 500 pounds, and the purchase of a truck exclusively for this amount of business is obviously not necessary.

In any revision of these estimates, to show a lower capital investment requirement, it should be kept in mind that annual operating costs will need revision to show rentals of buildings and also to show the costs of other transportation facilities employed.

For the purposes of this brochure, fixed assets above the minimum requirements have been included in the estimates.

ESTIMATED COST OF FIXED ASSETS

Item	Estimated Cost	Actual Cost
Site	$ 1,000	$_____
Building	24,000	_____
Equipment	12,000	_____
Truck	2,400	_____
TOTAL ESTIMATED COST OF FIXED ASSETS	$ 39,400	$_____

DIRECT MATERIALS

It would not be practicable to manufacture in a small radio factory all the parts required to produce a radio receiver. The capital investment would be prohibitive. Moreover, the parts used can be purchased for less money than they can be produced in small quantities. In some countries, however, where there is a local steel industry or a local plastics plant, there may be legal restrictions against the production, purchase or use of items in competition with those industries. Such measures are enacted to protect the local industries in their early stages of development. In this brochure, the assumptions are made that the parts can be purchased at prices comparable to those applicable in the United States and that such purchases are therefore economical.

After the plant is operating efficiently, and producing 100 radio receivers per day, consideration should be given to the production of other electronic equipment. For this purpose, a careful study should be made to determine the selection best adapted to small plant production, which, in addition, will provide the greatest additional business. It is recommended that, at the same time, consideration be given to the production of various types of electric equipment, using purchased parts, as a means of developing and expanding the radio plant's production capacity. Other items, the production of which require similar facilities, should also be considered.

It is intended that the radio parts will be purchased in bulk, not in sub-assemblies or kits. The exception would be in the case of special orders for electronic instruments for which the plant stock does not include all the required parts. Exception might be made for other models of receiver, of which the factory will probably make a few. These exceptions constitute additional business for the plant that is not included in the estimates. The following list is typical and shows the parts in a single Arkay S5E receiver. The parts for other models of receivers will not be the same, nor will those of other manufacturers. The model to be made in the proposed plant may differ if, for example, it is decided to manufacture transistor equipped receivers, or if other changes are adopted. The list as given is, however, illustrative, and is used as the basis of the estimates herein.

The following parts, and items, will be required for the initial steps of the project:

ESTIMATED ANNUAL COST OF PARTS AND MATERIALS

Items (Include related parts)	Estimated Annual Cost	Actual Annual Cost
Resistors	$ 10,000	$_____
Condensers	32,500	_____
Hardware	5,000	_____
Transformers	75,000	_____
Cabinet	50,000	_____
Carton	37,500	_____
Tubes (amplifiers)	100,000	_____
Hook-up wire and other	93,000	_____
TOTAL ESTIMATED ANNUAL COST OF PARTS AND MATERIALS	$ 403,000	$_____

RADIO RECEIVER PARTS LIST

Quantity	Description
Condensers	
1	50 + 30 @ 150 volts
2	.02 microfarads
2	.1 microfarads
1	.002 microfarads
2	.00025 mf (250 mmf)
1	.0001 mf (100 mmf)
Resistors	
1	150 ohms (brown, green, brown)
1	1200 ohms (brown, red, red)
1	22K ohms (red, red, orange)
2	470K ohms (yellow, purple, yellow)
2	3.3 meg (orange, orange, green)
Hardware List	
Note: rivets may be used for mounting	
12	4/40 x 3/8" screws
4	6/32 x 3/8" screws
3	6/32 x 1/2" screws
12	4/40 nuts
4	6/32 nuts
2	3/8" nuts
3	Spacers #6 x 3/8"
2	3/8" grommets
2	#6 x 5/8 self tapping screws
Additional Parts	
1	Line cord
1	Chassis
2	I.F. transformers
2	I.F. transformer clips
1	Volume control and switch
1	Dial face plate
1	Dial pointer
1	Oscillator coil
1	Variable condenser and drum
2	Knobs
1	Output transformer
1	Loud-speaker
1	Loop antenna
1	Dial Lamp assembly
1	Pilot Light
1	Dial drive
1	Length of dial cord
1	Dial spring
5	Tube sockets

RADIO RECEIVER PARTS LIST (continued)

Quantity	Description
Tubes	
1	Tube 12SA7
1	Tube 12SK7
1	Tube 12SQ7
1	Tube 50L6
1	Tube 35Z5
Cabinet	
1	Cabinet
1	Dial Window
1	Cabinet back
4	Trimounts (cabinet back clips)
Wire	

The wire will be received in coils. From this wire there will be manufactured the required hook-up pieces.

54	Hook-up pieces

PATENTS

It should be noted that some printed circuits, used in connection with oscillator coils, are protected in the United States by patents. Other component parts used in the manufacture also may be patented. Patent restrictions may be provided in other countries also. The restrictions apply in the country where the patent is granted. In the country where the small radio manufacturing plant is built there may be no restriction on copying an article patented in another country, but this lack of restriction may not apply to goods that are exported. The restrictions of the country into which the goods are sent will apply. Similar conditions apply to special marks and trade names which are patented. Licenses are usually issued by the owner of the patent for small royalties on goods thus copied and manufactured and shipped into the country where the patent was granted.

SUPPLIES

It is important to have on hand a complete set of replacements for the most vulnerable parts of the operation. These and other essential supplies listed below should be replaced whenever a carefully determined minimum is reached. The radio repair parts are for custom and repair work.

ESTIMATED ANNUAL COST OF SUPPLIES

Item	Estimated Annual Cost	Actual Annual Cost
Solder and flux	$ 1,000	$_____
Radio repair parts and plant repairs	1,700	_____
Hardware, including tools	300	_____
Office supplies	300	_____
Other, including supplies for truck operation	700	_____
TOTAL ESTIMATED ANNUAL COST OF SUPPLIES	$ 4,000	$_____

DIRECT LABOR

Radio receivers can be constructed from the various parts by workmen who have the ability to handle simple tools and follow instructions carefully. It is not necessary for them to have completed education in science, nor do they need long training in the technology of electronic projects. A radio receiver can be constructed very simply by the method described in this brochure. The ample space allowance, the simplified wiring plan, the step-by-step, three stage procedure, and the progressive inspection and testing make it easy to isolate and correct any incompetence. It has been demonstrated that women are often able to develop speed, accuracy and quality in the soldering that constitutes a large part of this work.

Manufacturers experience in the United States has established the fact that the radios to be produced in the proposed prototype plant can be built up from the separate parts at the rate of one radio per person per hour, as a sustained performance.

For the purposes of the prototype plant, with much smaller production, it has been assumed that this assembly will not be done so efficiently. An allowance of 44% extra time is made, thus requiring 144 man-hours work per day for this assembly. On the basis of an 8 hour day, 18 persons would be required in the assembly line. If a team of workers is established for each stage, each item would comprise 5 unskilled workers and one semi-skilled.

In addition, 3 teams of 3 unskilled workers each, would be required for the preparation of the sub-assemblies, and 1 semi-skilled person for inspection.

Receiving and shipping would require two persons, one of them to be competent and responsible. Both would use the handlift hydraulic trucks and both would participate in handling goods to and from conveyor and stores. There would be one semi-skilled person as stock keeper.

All would participate in arranging goods so as to facilitate the work of creating sub-assemblies from the bulk packages of goods received.

The wage rates shown are higher than those shown in the most recent publication of the U. S. Department of Labor covering these industries. They may not be as high as some top scales being paid in American Electronics industries in the current competetive situation. They are higher than would be paid in other countries.

DIRECT LABOR DISTRIBUTION

Function	Unskilled	Semi-Skilled
Stores		1
Receiving, shipping and final inspection	1	1
Sub-assembly and inspection	9	1
Assembly and inspection	15	3
TOTAL = 31 PERSONS, AS FOLLOWS:	25	6

ESTIMATED ANNUAL COST OF DIRECT LABOR

Allowing for holidays, vacations and maintenance, the direct labor will be paid for about 2,000 hours per week.

Type of Work	Workers Needed	Hourly Rate	Estimated Pay	Actual Pay
Semi-skilled	6	$ 2.00	$ 24,000	$_____
Unskilled	25	1.50	75,000	_____
	31			
TOTAL ESTIMATED ANNUAL COST OF DIRECT LABOR			$ 99,000	$_____

KEY MEN

The manager is the only person who must be a competent radio technologist. He is the key man.

The semi-skilled men should include at least 3 who have a working knowledge of the radio parts and who have acquired competence in the construction of the receiver described in this brochure. If other work is undertaken, and it is beyond the competence of regular personnel, then arrangements should be made to meet the additional requirements. The cost of such arrangement is not included in the estimate.

ESTIMATED ANNUAL INDIRECT LABOR

Item	Persons Needed	Estimated Salary	Actual Salary
Manager (Technology expert)	1	$ 8,000	$_____
Bookkeeper (Secretary)	1	6,000	_____
Utility man (truck & maintenance)	1	4,000	_____
TOTAL ESTIMATED ANNUAL COST OF INDIRECT LABOR	3	$ 18,000	$_____

TOTAL ESTIMATED ANNUAL COST OF LABOR

Item	Persons Needed	Estimated Cost	Actual Cost
Direct labor	31	$ 99,000	$_____
Indirect labor	3	18,000	_____
ESTIMATED TOTAL ANNUAL COST OF LABOR	34	$117,000	$_____

SAFETY

GENERAL

First aid kits and supplies should be readily available. One complete kit should be kept in the manager's office so that he can take immediate action in the case of accident. Special kits should be kept close to the testing operations. The bookkeeper should be made responsible for routine checking of the first aid kits to make sure that any supplies which have been used are replaced.

Special provisions should be made for the treatment of burns, electric shock and cuts.

Fire extinguishers should be easily available and fire drills should be conducted about once a month to train the employees as to the responsibility of each one in case of fire.

The manager should make frequent inspections to look for, and correct fire hazards, accident hazards, and unsafe practices. He should be familiar with first aid treatments and any action required in case of fire, electric shock or other accidents. The manager should take some specific action at least once each month to bring to the attention of each employee the importance of safety precautions and intelligent first aid.

It is recommended that the employees be encouraged to offer suggestions or recommendations relative to prevention of accidents, removal of fire hazards and maintaining general interest in all safety factors.

SPECIAL PRECAUTIONS

Radio receivers and other electronic devices are operated by electricity and in some circuits the voltage is high. Practically all of the personnel will have occasion to be careful in his work at one time or another because of the hazard of electric shock. For this reason, they may become indifferent and so the manager must, on his own responsibility, take special precautions with respect to the plant's electrical installations, the electric soldering irons, instruments and other equipment, the hazards connected with assembling and inspecting parts and particularly with respect to the attitude of each worker.

TRAINING

Of the 34 people employed in the proposed small radio manufacturing plant, it has been stipulated, in estimating the cost of personnel, that the manager is the "only one who must be a competent radio technologist". It is necessary that he shall be fully qualified in order to be acceptable as manager. The bookkeeper and the utility man, both specialists in their field, also should be fully qualified before they are employed. Six semi-skilled persons "should include at least three who have a working knowledge of the radio parts and who have acquired competence in the construction of the receiver described in this brochure." Without the ability to meet these requirements, they would not qualify for the higher rate it is proposed to pay them. All trainees for the higher rate should be paid the lower rate until they are fully qualified, if they are employed at all. Their preliminary training may be afforded by previous work, or at a suitable school or may be undertaken by the manager prior to the initiation of full-scale operation of the radio manufacturing plant.

These six people will be responsible for inspection, testing, repair of parts and finished product and for whatever other tasks may be assigned. They also will be responsible for training the remaining personnel in the various tasks of mounting, assembling, and otherwise manufacturing the receivers.

It has been pointed out that the work of assembling the parts of the radio receiver to be manufactured in the proposed plant is not the type of work that calls for skilled workmen. It is under the direction of a skilled workman who knows how it is to be done, and who shows a selected group who have a working knowledge of the radio parts and who have acquired competence in the construction of the receiver. The work of training the other employees can be divided among the members of this competent group.

Each of these leaders will show his share of trainees how to do all the processes. The work will first be divided amongst the teachers so that it is all covered and none duplicated. Then each trainer's work is further subdivided amongst individual workers, so there is no overlap and no part about which all workers are uninstructed.

The result will be that each person will do just what his instructor said should be done. It is not necessary for him to know why he does certain things, nor is it necessary for him to know what other things are done and why. He is not permitted to introduce any variations. Speed and accuracy are quickly acquired, or a different person chosen to do the work.

In many places women have demonstrated particular skill in the work.

ESTIMATED ANNUAL DIRECT OPERATING COST

Item	Estimated Cost	Actual Cost
Direct materials	$ 403,000	$
Direct labor	99,000	
TOTAL ESTIMATED ANNUAL DIRECT OPERATING COST	$ 502,000	$

ESTIMATED ANNUAL INDIRECT OPERATING COST

Item	Estimated Cost	Actual Cost
Indirect labor	$ 18,000	$
Supplies	4,000	
Power	1,000	
Water	40	
Fuel	200	
Freight	2,000	
TOTAL ESTIMATED ANNUAL INDIRECT OPERATING COST	$ 25,240	$

TOTAL ESTIMATED ANNUAL OPERATING COST

Item	Estimated Cost	Actual Cost
Direct operating cost	$ 502,000	$
Indirect operating cost	25,240	
TOTAL ESTIMATED ANNUAL OPERATING COST	$ 527,240	$

ESTIMATED WORKING CAPITAL

	Estimated	Actual
It is assumed that most of the parts, supplies and other material will require considerable time for delivery. To cover this, about one months' proportion, or about 1/12 of $403,000 is allowed. (Say)	$ 34,000	$_____
In view of the fact that it is important to maintain a steady production schedule, at times it may be advisable to produce at a faster rate than deliveries are made. It is also necessary to make allowance for the time required for collections on sales. This would make it advisable to have allowance for 1/12 of the annual operating cost as surplus finished stock, plus $10,000 for sales collections. (Say)	44,000	_____
TOTAL ESTIMATED WORKING CAPITAL REQUIRED	$ 78,000	$_____

TOTAL ESTIMATED CAPITAL REQUIRED

	Estimated	Actual
Total estimated fixed assets	$ 39,400	$_____
Total working capital required	78,000	_____
TOTAL ESTIMATED CAPITAL REQUIRED	$ 117,400	$_____

ESTIMATED DEPRECIATION

Item	Estimated Cost	Life in Years	Estimated Annual Depreciation	Actual Depreciation
Building	$ 24,000	20	$ 1,200	$_____
Equipment	12,000	15	800	_____
Truck	2,400	4	600	_____
TOTAL ESTIMATED ANNUAL DEPRECIATION			$ 2,600	$_____

SALES

There are several methods of sales distribution that may be used, depending upon local conditions.

In some countries it might be advantageous to give a large distributor exclusive sale of the radios. In other countries it might be preferrable to deal through several distributors located in various cities in the country.

There may also be conditions in come countries that would require the factory to sell direct to the retailer in at least some of the areas, in order to get full sales coverage.

It is recommended that one or more distributors be used where this is feasible. There will always be certain technical questions asked by the customer, particularly in countries where electronic products are not in general use. Such questions would generally be answered by the distributors and thus relieve the factory of this responsibility.

A very careful survey and study of all factors pertaining to sales should be made before selling policies and methods are established. One of the policies to be determined will be the retail price. One of the principle factors in determining the retail price will be the competitive retail prices of imported radios.

The total estimated cost, including sales cost and profit, of one radio receiver, produced in this plant is $26.80.

TOTAL ESTIMATED ANNUAL SALES = 25,000 SETS AT $26.80 = $670,000.

RECAPITULATION OF COSTS, SALES AND PROFITS

Items	Estimated Annual Costs		Actual Annual Costs
Direct materials	$ 403,000		$
Direct labor	99,000		
TOTAL DIRECT OPERATING COST		$502,000	$
Indirect labor	$ 18,000		$
Supplies	4,000		
Other indirect operating costs	1,440		
TOTAL INDIRECT OPERATING COST		$ 23,440	$
Depreciation	$ 2,600		$
Insurance	120		
Legal and auditing	240		
Bank charges	160		
TOTAL COST OF BURDENS		$ 3,120	$
Sales expense		$ 30,000	$
Unforseen		9,440	
Profit before taxes		102,000	
SALES, 25,000 SETS AT $26.80		$670,000	$

The sale of parts and accessories will provide additional profit, which is not included in the figure shown.

BUDGET CONTROL

A requisition form, page 39, is designed to provide accurate records and control of costs, both direct and indirect, with the least expenditure of time and effort.

This form has an account number for each type of the various expenditures which the manager will review in detail, monthly or oftener, in order to control his expenses. Some items, such as power, water, and fuel, are usually under contract and are easily checked by reference to monthly bills. For simplification, these and some other items (marked with an asterisk on the attached list) are omitted from the purchase requisitions. Variations in the labor costs are easily reviewed by examination of the payroll. The amplified type of control thus provided makes certain that the manager can control expenditures promptly.

At the end of each month the manager will receive a statement of all expenditures broken down by budget accounts. If the expenditures exceed the budgeted monthly allowance on any of the accounts, the bookkeeper will furnish the manager a breakdown of all expenditures relative to the budgeted accounts exceeded. All these supporting data can be secured by reference to the purchase requisitions. This reference will enable the manager to determine what caused the over-expenditure and take corrective action.

If, at any time during each month, it becomes apparent that expenditures will exceed any of the budget accounts, the bookkeeper will bring this to the attention of the manager for his information and action.

BUDGET CONTROL ACCOUNTS

Account Number	Item	Monthly Expenditure	Monthly Budget	Annual Budget
10	Administration	$_____	$ 260	$ 3,120
20	Sales	_____	2,500	30,000
30	Maintenance - Repairs	_____	17	200
*40	Power	_____	83	1,000
*41	Fuel	_____	17	200
*42	Water	_____	3	40
50	Material	_____	33,583	403,000
60	Supplies	_____	333	4,000
*70	Labor - Direct	_____	8,250	99,000
*71	Labor - Indirect	_____	1,500	18,000
80	Accessories	_____	_____	_____
90	Unforeseen	_____	787	9,440
100	Special Project	_____	_____	_____
			$ 47,333	

Note: Number 10 includes legal, insurance, interest and depreciation.

* Omitted from the purchase requisition.

PURCHASE REQUISITION	RADIO PLANT	DATE:

INDICATE BELOW THE DEPARTMENT OR PROJECT IN WHICH THE MATERIAL WILL BE USED:

( ) 10 ADMINISTRATION
( ) 20 SALES
( ) 30 MAINTENANCE
( ) 50 MATERIALS
( ) 60 SUPPLIES
( ) 80 ACCESSORIES
( ) 90 UNFORSEEN

INDICATE BELOW THE USE OF THE MATERIAL

( ) DIRECT MATERIALS
( ) INDIRECT MATERIALS
( ) OPERATING SERVICES
( ) MAINTENANCE SERVICES

SPECIAL PROJECT
100
NUMBER
TITLE
DESCRIPTION

PLEASE ORDER THE FOLLOWING MATERIAL, OR SERVICES:

DELIVERY WANTED:

QUANTITY	DESCRIPTION	UNIT	TOTAL	

QUOTES FROM

REQUISITION BY:

APPROVED BY:

ORDER PLACED WITH:

ORDER NO.

ORDER DATE:

SUMMARY

A small radio manufacturing plant built and operated to manufacture radios, according to the assumptions made in this brochure, would be a profitable undertaking.

There are some determinations, however, that should be made before a decision is reached to build and operate such a radio manufacturing plant. Among the necessary determinations are those with respect to the following items:

SALES

Will the potential annual sales amount to at least $670,000?

COSTS

After revising the estimates of cost and earnings shown in the brochure, so they conform to actual local costs where it is proposed to build the plant, will a profitable operation be indicated?

COMPETITION

Is there potential competition which will reduce the revenue below a profitable level either by lowering prices, or by reducing the volume of sales?

ORGANIZATION

Is there reasonable assurance that an experienced man will be available for management to initiate operations? Will suitable trainees be available for the permanent organization? The man in the manager's post should be trained in advance of the initial operation of the plant.

A small radio manufacturing plant, such as described in this brochure, when installed and operating, will serve as a good nucleus for a much larger industry when a larger plant is justified. The transition can be made by gradual growth.

Additional types of radio and other electric apparatus can be manufactured and sold when the volume of sales would justify such expansion.

Since the manufacturing equipment comprises a number of items that are standard in many factories, it is quite possible that the plant will develop a variety of products in response to local demands.

REFERENCES

A vast amount of reference material is available from which useful information can be drawn by those who are interested in establishing and operating small radio manufacturing plants. It is not practicable to list in this brochure all the books and periodicals where such information can be found. It is intended to list only a few, selected from among many, and to suggest that others, equally useful, may be found in local libraries or book stores, or may be suggested in response to inquiries at any appropriate source.

BIBLIOGRAPHY

The promotion, financing, construction and operation of a small radio receiver manufacturing plant apparently has not been the subject of any recently published volume. Discussions of some parts of the procedures involved are much the same as they would be for any other industry and in that form they can be readily found. An informative review of the history of the development of radio receivers is to be found in the Encyclopedia Britannica, together with other information about selectivity and quality of reception, diagrams of certain receivers, and other pertinent data.

The techniques for assembling, rivetting, wiring and soldering are widely used operations and most of them are described in standard textbooks and handbooks. Special details of some processes will vary according to the materials and equipment used. Suppliers will furnish adequate instructions for each.

A partial list of other reference books follows:

The Radio Amateurs Handbook,
Published by the American Radio Relay League,
West Hartford, Connecticut.

Basic Electronics, 5 volumes, by Van Valkenburgh, Nooger and Neville, Inc.,

Getting Started in Amateur Radio, Julius Berems,
John F. Rider Publisher, Inc.,
116 West 14th Street,
New York 11, New York.

Manufacturing Processes, by N. L. Begeman,
Mechanical Engineers Handbook,
John Wiley and Sons, Incorporated,
440 - 4th Avenue,
New York 16, New York.

The Primer of Electronics by D. P. Cavelry,
Elements of Electronics by Henry V. Hickey,
Electronic Engineering by Samuel Seely,
Practical, Industrial Electronics Library,
Plant Engineering Handbook,
McGraw-Hill Book Company,
330 West 42nd Street,
New York 18, New York.

Jigs and Fixtures for Mass Production,
Pitman Publishing Corporation,
2-6 West 45th Street,
New York 19, New York.

Electronics Made Easy; Lothar Stern,
Popular Mechanics Press,
200 East Ontario Street,
Chicago 11, Illinois.

Electronic Fundamentals and Applications by Professor John D. Ryder,
Prentice-Hall,
Englewood Cliffs, New Jersey.

Radio Electronics Made Simple, by Martin Schwartz,
American Electronics Company - 1956.

Electronics for Everyone, by Monroe Upton,
Devin - Adair - 1954.

Miscellaneous books on electronics may be secured from these, and other publishers:

Gernsback Library, Incorporated,
154 West 14th Street,
New York 11, New York.

Philosophical Library, Publishers,
15 East 40th Street,
New York 16, New York.

Rinehart and Company, Incorporated,
232 Madison Avenue,
New York 16, New York.

Supreme Publications,
1760 Balsam Road,
Highland Park, Illinois.

Government publications include some related textbooks on army training courses, a brochure on A Plastics Molding Plant, by the Foreign Operations Administration, and, particularly, the following:

Shipboard Electronic Equipments,
Bureau of Naval Personnel.

Basic Electronics, Navy Training Courses,
Electronics Technician 2,
Electronics Technician 3.

These navy electronic books may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

PERIODICALS

Information is published on many subjects which are of interest to persons who are considering the establishment and operation of a small radio manufacturing plant. Much of this published information appears in periodicals. It is, of course, only a relatively small part of the material in such publications as none are devoted exclusively to the publication of data about such plants. Some of the information of interest may be about the finances involved in radio manufacturing, some may be about management, or sales. In view of the unusual technical character of the product, and due to the fact that the persons seeking information on which to base decisions are not generally versed in the science of electronics, it is probable that the descriptions and discussions written for the layman will be of most interest and will convey the most information. The following magazines are among those which contain such material:

Popular Mechanics Magazine,
200 East Ontario Street,
Chicago 11, Illinois.

Popular Science,
353 - 4th Avenue,
New York 10, New York.

Popular Electronics,
Radio and Television News,
Ziff-Davis Publishing Company,
64 East Lake Street,
Chicago 1, Illinois.

Radio Electronics,
Gernsback Publications Incorporated,
Mt. Morris, Illinois.

Science and Mechanics,
450 East Ohio Street,
Chicago 11, Illinois.

Scientific American,
415 Madison Avenue,
New York 17, New York.

Electronic Industries and Tele-Tech,
Chilton Company,
Chestnut and 56th Streets,
Philadelphia, Pennsylvania.

Electronics,
McGraw-Hill,
330 West 42nd Street,
New York 36, New York.

Electronic Technician and Circuit Digest,
Electronic Technician, Incorporated,
Emmett Street,
Bristol, Connecticut.

John F. Rider Publisher, Incorporated,
116 West 14th Street,
New York 11, New York.

Institute of Radio Engineers (Proceedings),
1 East 79th Street,
New York 21, New York.

Information, often of a technical nature, is to be found in the publications of various technical societies and in trade journals. Some of the manufacturers and suppliers also publish house organs and catalogs that are good sources of general information and data regarding specific component parts and supplies.

MANUFACTURERS AND SUPPLIERS OF RADIO PARTS,

EQUIPMENT AND SUB-ASSEMBLIES

There are a great many manufacturers and suppliers of radio parts and equipment. Many more, in fact, than would be practicable to include in a list in this brochure. The addresses of a few are given, however, for convenient reference. Others can be located by reference to various directories, and by inquiry through the appropriate organizations and associations.

Reference is made to the trade directory of the Electronic Industries Association. The headquarters of this Association is located at 1721 DeSales Street, N.W., Washington 6, D. C. The association will furnish information about which members will be the appropriate ones to whom inquiries about specific electronic needs should be addressed. More than a hundred members are listed in the Parts Division Section Membership in the current issue of their directory and a few are given below. The association has several departments, including an Engineering Department, and an International Department, both of which are concerned with overseas projects, but not particularly with the initiation of small radio manufacturing plants in foreign countries. Not all of the companies whose addresses are given are members of the Electronic Industries Association.

Allen-Bradley Company,
136 West Greenfield Avenue,
Milwaukee 4, Wisconsin.

Amphenol Electronics Corporation,
1830 South 54th Avenue,
Chicago,44, Illinois.

Centralab, A division of Globe Union, Incorporated,
900 East Keefe Avenue,
Milwaukee 1, Wisconsin.

Chicago Condenser Corporation,
3255 West Armitage Avenue,
Chicago 47, Illinois.

Clarostat Manufacturing Company, Incorporated,
Washington Street,
Dover, New Hampshire.

Collins Radio Company,
855 - 35th Street, N. E.,
Cedar Rapids, Iowa.

Consolidated Wire and Associated Companies,
1635 South Clinton Street,
Chicago 16, Illinois.

Cornish Wire Company, Incorporated,
50 Church Street,
New York 7, New York.

Drake Manufacturing Company,
1713 West Hubbard Street,
Chicago 22, Illinois.

General Cement Manufacturing Company,
Division of Textron, Incorporated,
400 South Wyman Street,
Rockford, Illinois.

General Electric Company,
570 Lexington Avenue,
New York 22, New York.

The General Industries Company,
Taylor and Olive Streets,
Elyria, Ohio.

International Rectifier Corporation,
233 Kansas Street,
El Segungo, California.

International Resistance Company,
401 North Broad Street,
Philadelphia 8, Pennsylvania.

Jensen Manufacturing Company,
6601 South Laramie Street,
Chicago 38, Illinois.

J.F.D. Electronics, Incorporated,
6101 Sixteenth Avenue,
Brooklyn 4, New York.

Littelfuse, Incorporated,
1865 Miner Street,
Des Plaines, Illinois.

P. R. Mallory & Company, Incorporated,
3029 East Washington Street,
Indianapolis 6, Indiana.

Merit Coil & Transformer Corporation,
4427 North Clark Street,
Chicago 40, Illinois.

Ohmite Manufacturing Company,
3601 West Howard Street,
Skokie, Illinois.

Oxford Electric Corporation,
3911 South Michigan Avenue,
Chicago 15, Illinois.

Radio Corporation of America,
30 Rockefeller Plaza,
New York 20, New York.

Raytheon Manufacturing Company,
Waltham 54, Massachusetts.

Sprague Electric Company,
87 Marshall Street,
North Adams, Massachusetts.

Sylvania Electric Products, Incorporated,
1740 Broadway,
New York 19, New York.

Westinghouse Electric Corporation,
3 Gateway Center,
P. O. Box 2278,
Pittsburgh 30, Pennsylvania.

Attention is called to the following suppliers for the reasons shown. One of the best methods of expansion of the small radio manufacturing plant in a foreign country would be the addition of other models of radio receivers, and other electronic devices in addition to the one on which the estimates in this brochure are based. Such expansion should be undertaken after the initial plant has become established. The potential sales of the added lines might not be determined in advance and initial production would probably not be great enough to warrant the purchase materials and parts in bulk. Purchase of materials for such small orders designed for various circuits can be made from firms specializing in meeting such demands. The required parts and materials for each instrument are collected in separate packages known as kits as stipulated by the purchaser and the completion of the manufacturing and assembling is done by the purchaser.

This plan is followed by many companies and individuals. Some of the suppliers of radio parts specialise in this business. Some domestic sources of supply for radio parts available to foreign manufacturers are listed as follows:

Electronic Instrument Company,
330 Northern Boulevard,
Long Island, New York.

Heath Company,
Benton Harbor 20, Michigan.

Precise Development Corporation,
Oceanside, New York.

Radio Kits, Incorporated,
(Build and supply small manufacturers abroad)
120 Cedar Street,
New York 6, New York.

International General Electric Company,
(Exports radio tubes)
150 East 42nd Street,
New York, New York.

Sylvan Ginsbury,-(Exports radio parts)
8 West 49th Street,
New York, New York.

Doge Corporation,-(Exports radio parts)
East 44th Street,
New York, New York.

Such relatively small purchases can also be made through other manufacturers and distributors.

ENGINEERS

The services of professional engineers are desirable in the design of a radio manufacturing plant, even though the proposed plant is small. This applies to the product, as well as to the plant.

A correctly designed plant is one that provides the greatest economy in the investment of funds and establishes the basis of operation that will be most profitable in the beginning and will also be capable of expansion without excessive alteration.

Product design is of such importance that it would not be undertaken by persons who are inexperienced and untrained in this work. This is particularly true of radio receivers, because of their design, which not only has a great effect on the sales, but probably will be just as important in determining the cost of manufacture. Appearance has an important part in the design, but a beautiful product may be worthless in use or impossible to manufacture economically.

Accordingly, the services of a professional radio engineer should be employed and he should be responsive to the requirements of appearance, as well as performance and cost of manufacture.

The addresses of professional engineers who specialize in manufacturing plant design, and of others who specialize in product design, some of whom may be willing to undertake such work in low cost projects overseas, can be secured by reference to the published cards in various engineering magazines. They may also be reached through their national organizations, one of which is the

National Society of Professional Engineers,
2029 K Street, Northwest,
Washington 6, D. C.

Such inquiries, together with inquiries for information on manufacturers, may be addressed to:

Institute of Radio Engineers,
1 East 79th Street,
New York 21, New York.

The Institute of Radio Engineers is the major professional organization and would reach the majority of radio and electronic engineers. Attention is called to the fact that professional cards appear in their monthly journal, which is called "Proceedings of the Institute of Radio Engineers".

Many parts manufacturers employ engineers on this type of work and are quite willing to assist in the solution of engineering problems, or in locating a responsible and qualified person who will undertake the solution.

GLOSSARY

This is a limited glossary of terms and names which may be used in connection with the consideration or discussion of this suggested prototype of a small radio manufacturing plant. Many of these definitions are incomplete or do not have sufficient definitive detail to satisfy a radio technician or engineer. They should consult a standard textbook or electronics dictionary. This is intended merely to provide a layman's version of some of the technical terms used in this brochure which will most likely be of interest to the government official, employee or advisor who may have occasion to read it, but who is not versed in electronics.

AMPLIFICATION. The process of increasing the strength of a signal.

AMPLIFIER. A device used to increase the signal voltage, current, or power, generally made up of a vacuum tube and associated circuit called a stage. It may contain several stages in order to obtain a desired gain.

ANODE. The electric element or electrode in a vacuum tube to which the electron stream flows: the plate of the vacuum tube; identified by the letter P.

ANTENNA. An electrical conductor for picking up, or radiating radio waves; an aerial. May be on a tower or pole, on the automobile, or roof top, or within the room. The loop-antenna, in the proposed set, is a coil within the cabinet. Another self-contained antenna is known as a core antenna.

AUDIBLE. Capable of being heard; a signal or vibrational disturbances of audio frequency and of sufficient strength to be heard.

AUDIO AMPLIFIER. Device to increase the audio-frequency signal.

AUDIO COMPONENT. That portion of any wave or signal whose frequencies are within the audible range.

AUDIO FREQUENCY. A frequency which can be detected as a sound by the human ear. The range of audio frequencies extends approximately from 20 to 20,000 cycles per second.

AUTOMATIC VOLUME CONTROL. A method of automatically regulating the gain of a receiver so that the output tends to remain constant though the incoming signal may vary in strength.

CAPACITANCE. The ability to store electrical energy, measured in farads, microfarads, or micromicrofarads.

CAPACITOR. Two electrodes, or sets of electrodes, in the form of plates, separated from each other by an insulating material called the dielectric.

CARRIER. See CARRIER WAVE.

CARRIER FREQUENCY. The frequency of an unmodulated carrier wave.

CARRIER WAVE. The r-f component of a transmitted wave upon which an audio signal, or other form of intelligence, can be impressed.

CATHODE. The electric element or electrode in a vacuum tube from which the electron stream flows; identified by the letter K.

CHASSIS. Base on which parts of a radio are mounted.

CONDENSER. A device to receive and hold an electric charge.

CONDUCTANCE. The ability of a material to conduct or carry an electric current. It is the reciprocal (opposite) of the resistance of the material, and is expressed in ohms.

CONTINUOUS WAVES. Radio waves which maintain a constant amplitude and a constant frequency, abbreviated c-w or CW.

DETECTION. The process of recovering the audio component (audible signal) from a modulated r-f carrier wave.

DIELECTRIC. An insulator. A term applied to the insulating materil between the plates of a capacitor.

FADING. Variations in the strength of a radio signal at the point of reception.

FIDELITY. The degree of accuracy with which a system, or portion of a system, reproduces in its output the signal which is impressed on its output.

FILTER. A combination of resistances, inductances, and capacitances, or any one or two of these, which allows the comparatively free flow of certain frequencies or of direct current while blocking the passage of other frequencies. An example of this is the filter used in a power supply, which allows the direct current to pass, but filters out the ripple.

FREQUENCY. The number of complete cycles per second existing in any form of wave motion; the number of cycles per second of an alternating current, or sound wave.

FREQUENCY MODULATION. The process of varying the frequency of an r-f carrier wave in accordance with the amplitude and frequency of an audio signal.

HETERODYNE. The action between two alternating currents of different frequencies in the same circuit; they are alternately additive and subtractive, thus producing two beat frequencies which are the sum of, and difference between, the two original frequencies.

HIGH FIDELITY. The ability to reproduce all audio frequencies between 50 and 16,000 cycles per second, without serious distortion.

HOOK-UP. Electric circuit connections.

INTERMEDIATE FREQUENCY. A frequency of a mixer output signal which is equal to the difference between the frequency of the antenna signal and the frequency of the signal from a local oscillator.

KILO. A prefix meaning one thousand.

KILOCYCLE. One thousand cycles per second.

LINE CORD. A two-wire cable, and plug, to connect a set with a wall out let.

LOOP ANTENNA. An antenna consisting of one or more complete turns of wire, designed for directional transmission or reception.

LUG. A metal strip for soldered connection.

MICRO. A prefix indicating one-millionth.

MILLI. A prefix indicating one-thousandth.

OSCILLATOR. A radio frequency generator; a device generating alternating current when fed direct current.

RADIO-FREQUENCY. A frequency above 20,000 cycles per second.

SCHEMATIC DIAGRAM. A diagram showing electric circuits by symbols.

SIGNAL. The controlled sound or other intelligency that is carried by radio waves from the sending station to the receiving station.

SPAGHETTI TUBING. Varnished cloth tubing for insulation.

TETRODE. A four electrode vacuum tube.

TRIODE. A three electrode vacuum tube.

VACUUM TUBE. Also called radio tube, electron tube, tube, thermionic valve, valve, diode, triode, tetrode or pentode. A sealed metal or glass tube from which the air has been exhausted and which contains electric elements called electrodes. They are used to control the flow of electrons in an electric circuit.

VOLUME. A term used to denote the sound intensity of a radio receiver or audio amplifier.

VOLUME CONTROL. A variable resistor to change the volume of sound from the loud speaker.

WAVE. The progressive movement (propagation) either of sound or electromagnetic waves through a conducting medium, as rhythmical disturbances.

SIGNALS AND SYMBOLS

LOOP ANTENNA 

GROUND OR CHASSIS CONNECTION 

TUBES

DIODE 

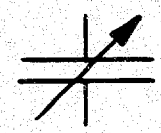
TRIODE 

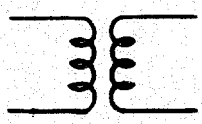
TETRODE 

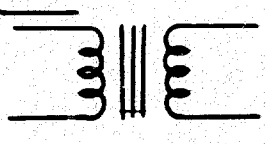
PENTODE 

RESISTOR (FIXED) 

RESISTOR (TAPPED) 

CAPACITOR 

TRANSFORMER (AIR CORE) 

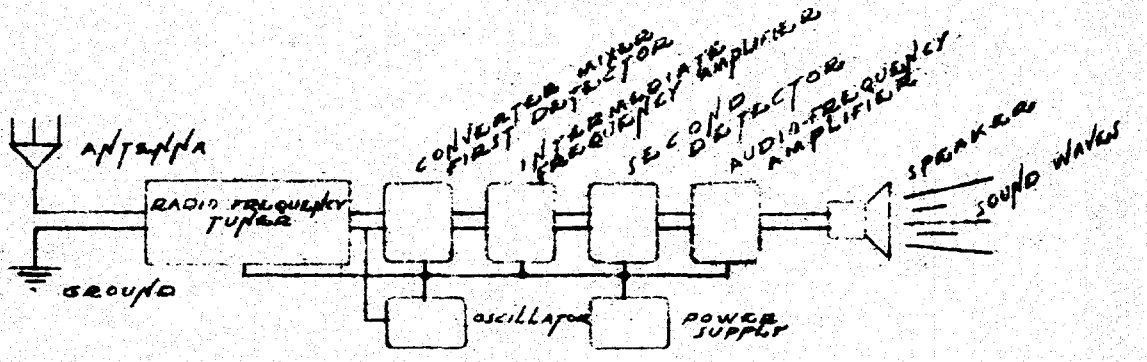
TRANSFORMER (IRON CORE) 

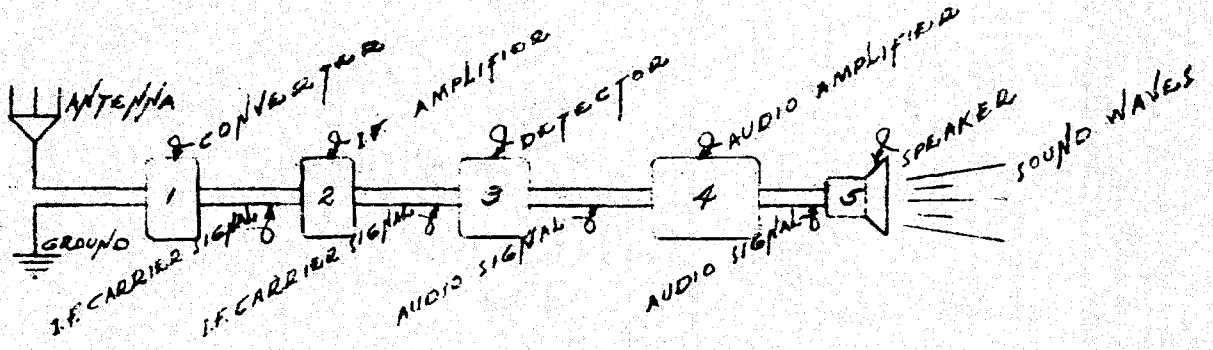
SPEAKER 

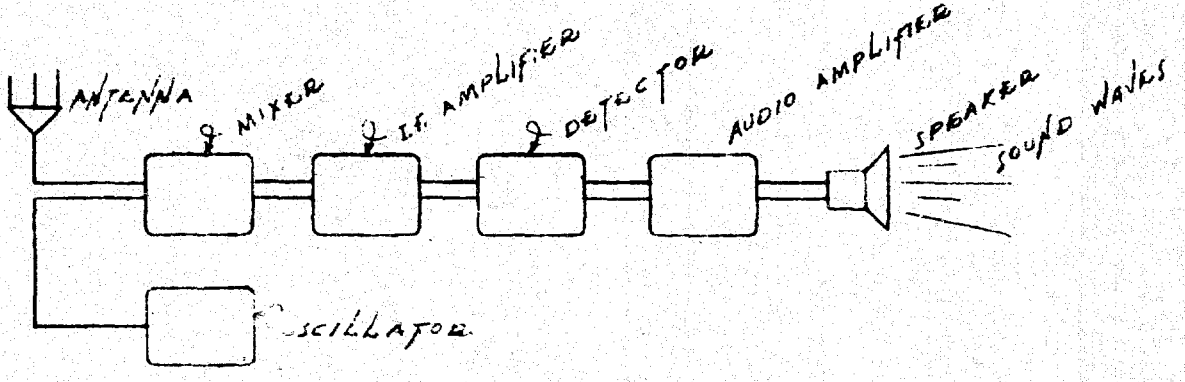
LINE CORD, WITH PLUG 

SUPERHETERODYNE RADIO RECEIVER

BLOCK DIAGRAMS







THESE DIAGRAMS ILLUSTRATE VARIOUS WAYS OF SHOWING A SUPERHETERODYNE CIRCUIT WHICH IS THE CIRCUIT USED IN THE MOST POPULAR RECEIVERS TODAY.

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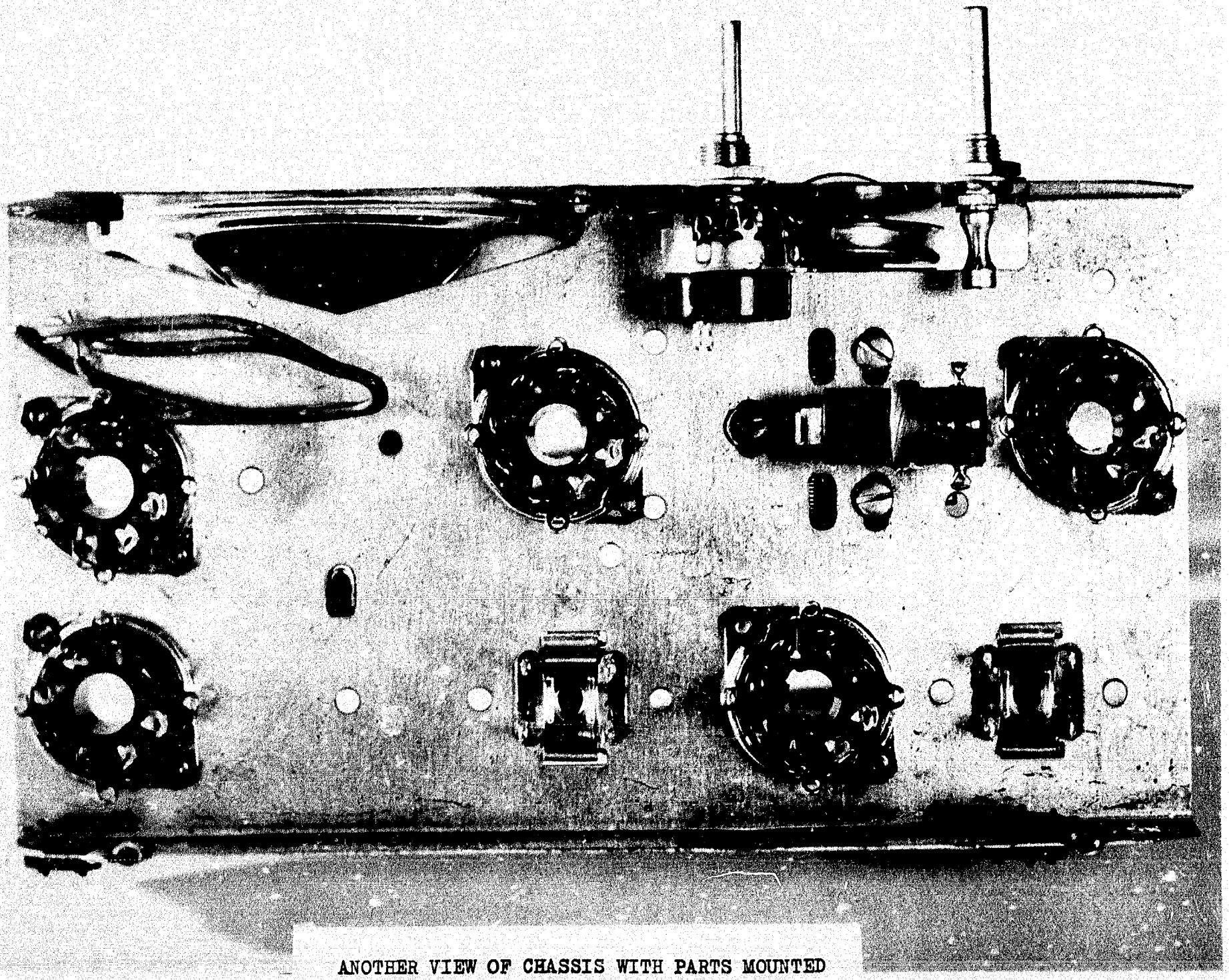
ADDITIONAL SUPERHETERODYNE RADIO RECEIVER BLOCK DIAGRAMS



ANOTHER VIEW OF CHASSIS WITH PARTS MOUNTED