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Development Meeting on the Manufacture
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(including low-cost receivers for sound
broadcasting and television)

Vienna, 13 - 24 October 1969

# DESIGNING AND MANUFACTURING LOW-COST RECEIVERS OF RADIO BROADCASTS IN DEVELOPING COUNTRIES[1/]

by

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Page [illegible]  Fourth paragraph, line three
read as "[illegible]"

Page 14  First line
Read as "devices, variable capacitors ..."

Page 22  Item No. [illegible], line six
delete "[illegible] test loop"

Page 23  Item No. 11, line five
add "[illegible] construction: [illegible]ble"

Item No. 12, line five
delete "1/2 [illegible]"

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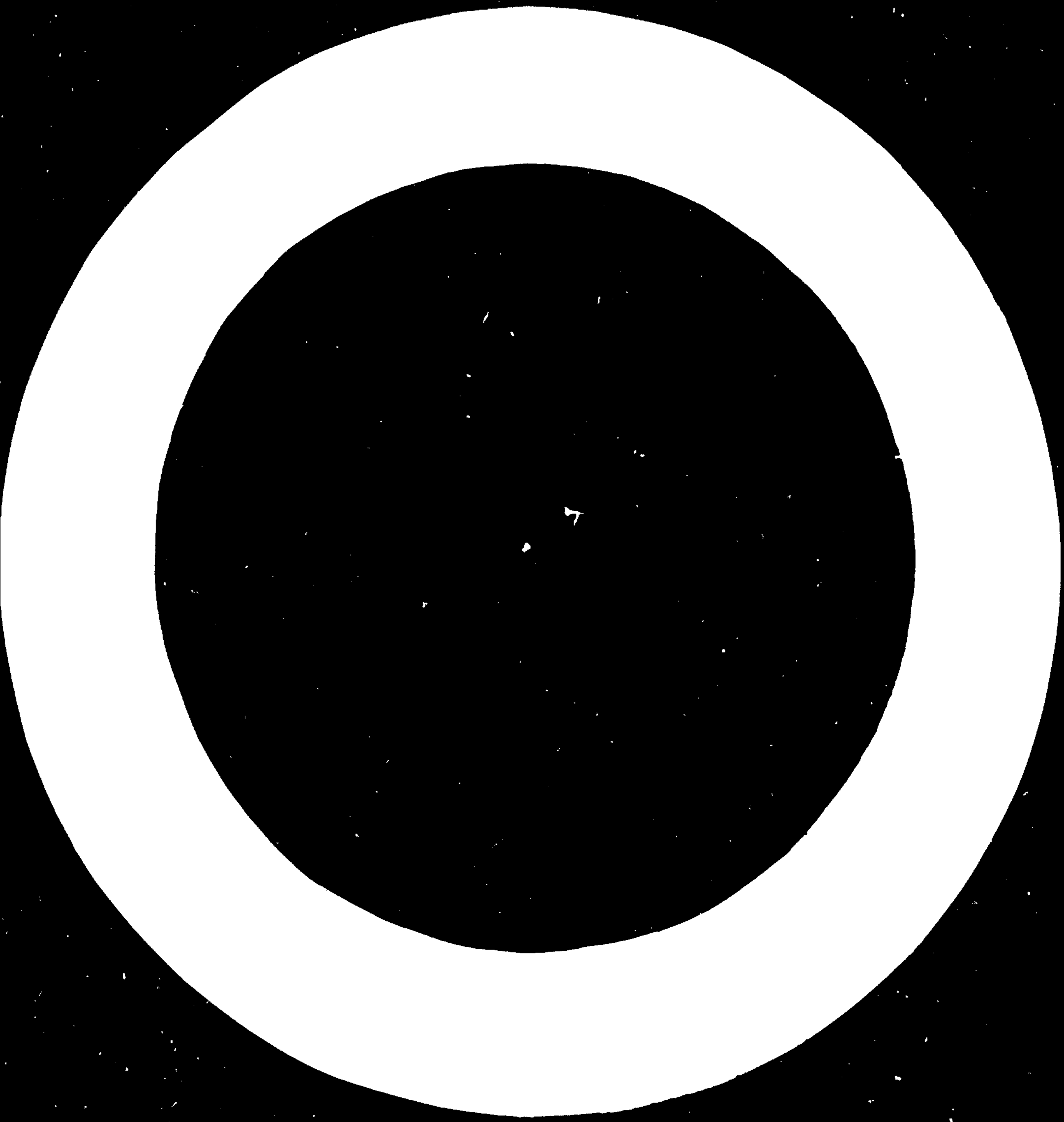


**Contents**

## 1. INTRODUCTION

Most radio receivers spread over world markets are presently manufactured in developed industrial countries with adequate production facilities under well-controlled conditions. Also, the radio industry is highly competitive--the same as any other industry. This simply implies that by all means radio receivers must be merchandise which reflects vigorous efforts to reduce costs.

Although radio receivers are generally included in the category of durable consumer goods, it may be inevitable for a consumer to adopt the inherent buying psychology of adding its external appearance to his selecting basis as well as its performance and reliability when he shops for a radio. That is, consumers are apt to form the basis of their buying decision on a balance between price, performance, and appearance.

Generally, surrounding market conditions may not be disregarded even in newly designing and manufacturing radio receivers in a developing country to gain the acceptance of the general public in that country. Additionally, the most important goal is that planning a radio production program must be based on positive data of potential demands and purchasing ability of the general public in that country; otherwise, the products may not gain public approval.

The main factors determining the cost of radio receivers are (1) design--both performance and external appearance; (2) production quantities per day or month, and size of each production lot; (3) purchasing price of material and components; (4) skill and wages of workers; (5) manufacturing facilities including testing equipment; (6) quality control; (7) after-service or guarantee; and (8) investment.

The above items are discussed in detail in the following chapters.

## 2. GENERAL

Radio receiver structure, in general, is divisible into two categories--(1) a circuit configuration which effects performance of the receiver, and (2) an enclosure or cabinet which determines external appearance. In reviewing these two categories from a cost standpoint, although the ratio of (1) to (2) varies widely based on individual cases, regarding comparatively simple receivers on the market, the ratio is around 60 to 40. In other words, the cabinet cost of such receivers may occupy approximately 40 percent of the total factory cost.

Several means are considered in reducing the cost of radio receivers for a special purpose manufactured and distributed in a developing country. Steps in designing low-cost receivers include (1) simplifying cabinet construction to an extreme without lowering performance, (2) lowering receiver performance specifications to an acceptable limit in accordance with circumstances of each country, and (3) using the least expensive components without affecting product reliability.

However, in designing receiver cabinets, general public preference of the country involved cannot be entirely disregarded, otherwise such products may have little or no appeal.

Regarding receiver performance specifications, the peculiar circumstances of the country--location of broadcasting stations, population distribution, power supply conditions, and weather conditions (especially thunderstorm frequency)--must be taken into consideration. Additionally, conditions of neighboring countries should not be ignored.

Nowadays, low-cost radio receivers can be designed by using semiconductor devices instead of vacuum tubes, resulting in lower prices, higher reliability, and lower power consumption.

Concerning the design procedure of transistorized radio receiver circuits, appropriate descriptions are available in certain text books sold in bookstores; thus, in the survey, descriptions are offered on a few definite examples. Receiver categories and specifications may be reviewed by referring to Recommendation 415 of the CCIR, 1963.

Three representative models (A, B, and C) are presented, and details of those models are described herein.

References;

a. Transistor Circuit Engineering by Richard F. Shea, published by John Wiley & Sons, Inc. 1957

b. Transistor Circuit Design by Joseph A. Walston et al. Published by McGraw-Hill Book Co., Inc.

Most circuit components and materials (including transistors, diodes, electrolytic capacitors, ceramic capacitors, variable capacitors, fixed and variable resistors, multicontact switches, speakers and ferrite components) are manufactured in developed industrial nations under a mass-production system, placed on the market at reasonable prices. Manufacturing these components and materials requires highly developed and skilled technology, using well-controlled facilities. In producing low-cost radio receivers in developing countries, necessary components are purchased from developed industrial nations, at least for the time being.

Radio receiver production cost is largely influenced by total and daily production quantities.

Especially in the case of relatively small-lot production, the influence is remarkable. In certain circumstances, where daily production is less than 300 sets, factory costs rise abruptly and the limit of an economical daily production rate may be around 400 sets (10,000 monthly).

Based on the above reason, a manufacturing plant for 10,000 sets monthly is discussed herein.

In selecting a factory site, location conditions including the traffic situation, power supply, water supply, and job orders must be considered.

Meeting a projected production schedule depends upon factory facilities together with level of skill and ability of the engineers, technicians, and workers. When radio receivers are to be manufactured in a developing country for the first time, special training of factory personnel may be required.

After the design work (including detailed drawings) and the parts listing (with specifications) are completed by the design section, a few trial production sets are manufactured and reviewed from all angles. As a result, the original design undergoes necessary modification. Following trial production, 50 or 60 preproduction sets are run through the production line, based on the modified drawings. After the same process of review is applied to these preproducts, regular production is started when results prove satisfactory.

Assembly work is broken down into certain jobs of each worker, and assembly guidance is prepared by the Production Engineering Section. The workload variety for each worker must conform with his skill. For the time being, about five types of mounting or wiring procedures may be appropriate. If too many work items are loaded on a worker, it is apt to foster discrepancies in production.

A belt conveyor system for assembling work (including mounting, wiring, and intermediate testing) is appropriate for producing more than several hundred sets per day.

Guarantee and after-sales service on products must be taken into consideration when preparing cost accounting estimates.

3. DESIGN

SPECIFICATIONS:

It is imperative that the design of radio receivers be based upon performance specifications. The degree of strictness exercised in maintaining performance specifications may affect the cost of the products on a large scale. Where field intensities of the radio broadcasting stations are strong, or where homes and apartments are limited to areas comparatively close to the stations, receivers of lower sensitivity--to a certain extent--may suffice in practical use. Where only a few broadcasting stations exist and severe interference from other radio transmitters and similar sources are not anticipated, receivers of lower selectivity may be useful. Since these conditions are singular to each country involved, it may not prove practical to establish performance specifications of the lowest cost receivers. Accordingly, concerning the lowest performance specifications which can be depended upon in such a project it is advisable to arrive at a decision by reviewing each individual case after giving due consideration to local conditions.

In this account, certain performance specifications for Type "A" (standard broadcast band), type "B" (standard broadcast and short wave bands), and type "C" (VHF frequency modulation band) are assumed as shown in Addendum 2 as the basis of design procedure, referring to CCIR Recommendation No. 415, 1963. Also taken into consideration are the results of our own broad experience, wherein assumed performance specifications differ somewhat from CCIR's publication, deduced from actual results of many examples of low-cost radio receivers in several developing countries which have met with public approval.

The most important point in designing low-cost radio receivers is to provide a sufficient allowance in specifications; otherwise, manufacturing procedures may require a critical alignment, causing the need for excessive manufacturing man-hours and extra components. Both these factors must be associated with higher cost. Economy-priced radio receivers are not always dependent on simple circuit design.

Radio receivers have been designed by using either conventional vacuum tubes or semiconductor devices (transistors and semiconductor diodes); however, today, semiconductor devices must be utilized from every angle--economy in manufacturing and operating costs, and reliability and safety in operation.

The theoretical procedure of circuit design for radio receivers has been adequately discussed in many books available at book stores (see chapter 2).

Success of designing low-cost radio receivers depends upon circuit design coupled with designing and selecting the components and materials to be employed. In selecting circuit components, design must be reviewed from every angle--cost, performance, reliability climate resistant and availability. Using low-cost components only by virtue of their low cost, while disregarding their performance and reliability, may cause receiver defects which inevitably lead to added expense. Certain obtainability must be confirmed at the design stage in selecting each component.

Cabinet design should desirably be simple and sturdy in construction, conforming to the general public's tastes. Where adequate plastic moulding facilities or woodworking facilities are available, it is advisable to design cabinets by considering the utilization of such industries.

In actually designing radio receivers, it may prove rational to conduct test and review every possible angle on certain working samples produced on a trial basis, the original designs subsequently revised to thoroughly reflect improvements suggested by the trial results.

The Design Section must submit detailed design drawings and a complete parts listing with specifications to the Manufacturing Section. An example of items required for low-cost radio receivers are included in Addendum 2 to this document.

4. MATERIALS AND COMPONENTS

Certain components of radio receivers are produced on the basis of a wide range of technology in developed industrial nations. Bearing this in mind, when developing countries manufacture low-cost radio receivers, it may be difficult for them to domestically produce the necessary whole components at the start which are required.

According to circumstances of the country's condition, it may prove advisable to initially manufacture receivers by assembling most of the parts, relying on imported circuit components.

In the following discussion, the subject of components is divided into two categories--components for cabinets and those for circuit configuration.

Most economy-priced radio receiver cabinets manufactured in developed industrial nations and placed on the market are made of plastic, simply to effect mass production and low labor cost. However, it may be advisable to consider the use of wood or plywood as cabinet materials, utilizing existing domestic industry if there are suitable woodworking facilities available. Utilizing this procedure, the initial stage of manufacturing the receivers would be eased, even though a suitable degree of plastic moulding has not yet become available in that country. It may not be economical to install the necessary plastic moulding equipment merely for the purpose of locally producing plastic radio cabinets. Three factors determine the effective design of low-cost radio cabinets in this instance:

(1) the use of easily procured materials, (2) simplified design without expensive ornamentation, and (3) facile assembling without the need of complicated processes.

Those parts utilized in receiver cabinets, such as the chassis, brackets, etc. can be easily self-produced by providing comparatively simple machines and tools.

Conversely, among the circuit components, there are many whose manufacture demands higher technology and expensive installation. Moreover, most of these components can be produced competitively only through mass production of which economically minimum quantities far exceed the individual requirements of a receiver manufacturer.

In the above category would be included semiconductor devices. Variable capacitors for tuning control, electrolytic capacitors, ceramic capacitors, ferrite components, multicircuit switches, speakers, and other components.

Developing countries possessing comparatively simple machines and tools may be able to produce AF and IF transformers, RF coils, film capacitors, simple switches, and so on. However, delicate materials such as ferrite components, resilient materials and chemicals must be imported from developed industrial nations to produce such components.

In conclusion, in the initial stage of manufacturing economy-priced radio receivers in developing countries, the above-mentioned delicate components and materials necessary for production should be temporarily imported, and it is advisable to gradually increase the categories of self-supporting components.

Concerning imports of components and materials, of course, the necessary specifications must be thoroughly reviewed. Utilizing component kits imported from developed industrial nations may prove to be a convenient method. In this case, use of only those kits which have already attained actual good results in mass-produced receivers is desirable.

5. FACTORY FACILITIES

Site and Scale:

The site and scale of factories for producing radio receivers are determined based on the type of receivers to be manufactured and the maximum daily production rate, estimating the power supply, water supply, and traffic. Incidental facilities such as employees quarters may be reviewed.

Taking a production capacity of 10,000 receiver sets per month (or 400 sets per day) as an example, the necessary net floor space for the assembling works may total around 2,400 square meters. In addition, affiliated facilities such as warehouses for products and purchased materials, a testing room, tool room, air compressor room, laboratory, office space, and dining hall will be required.

Installation:

Belt conveyor: In producing 10,000 receiver sets per month, a belt conveyor system should prove economical. Considering the space factor, a dual belt conveyor is convenient, with work benches arranged along each conveyor belt. As an example, an arrangement of belt conveyors and work benches are shown in Figs. 1 and 2, their specifications listed in Table 1.

Table 1 Specifications of Dual Belt Conveyor

| | |
|---|---|
| Length of belt conveyor (mm) | 30,000 |
| Effective total length (mm) | 60,000 |
| Belt width (mm) | 300 |
| Belt height above floor (mm) | 750 |
| Belt speed (m/minutes) | Adjustable within 0.5 - 2.0 |
| Driving motor | 0.75kW |
| Work benches | 900mm (W), 700mm (D). 750mm (H)<br>Plywood tops (48 required) |

Wiring and piping: From a viewpoint of employee safety, it is advisable to use AC, 100V - 120V for the power supply for soldering irons, test instruments, and room lighting. For easy adaptability in changing the assembling process, overhead wiring may prove convenient. High-pressure air piping from the air compressor room for operating pneumatic tools is required, its adaptability to subsequent layout changes also to be considered.

Shield room: Product precise performance tests must be conducted in a room free from external electrical disturbances. When strong interference from radio broadcasting signals, radio communications stations, industrial radio equipment, and so on is anticipated, an adequate shielded room having 100dB attenuation is required for testing. To attenuate radio interference within a range of frequencies of 400kHz through 400 MHz by 100dB, the test room may be constructed by very careful double shielding, utilizing wire mesh. The inner mesh and outer mesh are insulated and grounded at a common point. Where excessive interference is prevalent at the factory, the external power supply, must be introduced to the shield room through a low-pass filter; otherwise, alignment processing on the line may be disturbed. In such cases, a movable shielded room sized 1.8m x 1.8m x 1.8m may be required.

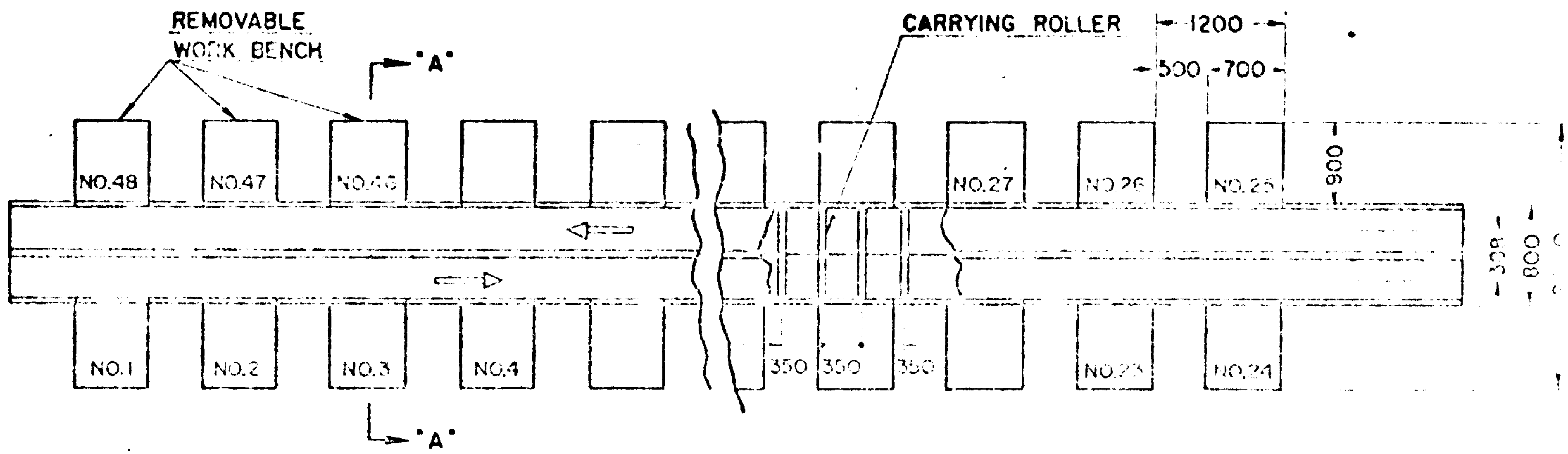
Air compressor: One air compressor set for the pneumatic tools is required, its specifications--

| | |
|---|---|
| Compressed air pressure | 10 kg/sq.cm |
| Power | 2kW |
| Tank capacity | 120 ℓ |

Measuring instruments: Specifications of measuring instruments required for producing low-cost radio receivers are shown in Table 1. The necessary quantity of sets for each receiver type is listed in Table 2.

FIG 1. DUAL BELT CONVEYER

PLAN




FIG

ELEVATION

(EXCLUDING WORK BENCH)

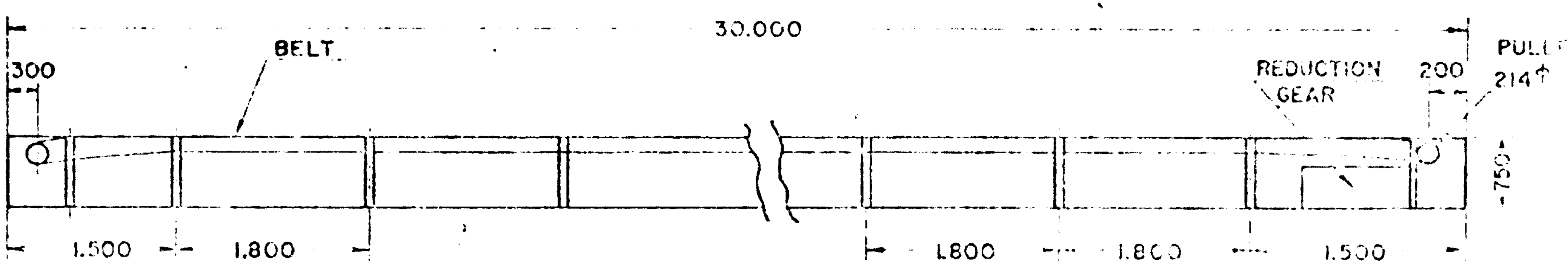


FIG 2

DUAL BELT CONVEYER
SECTION "A"-"A"

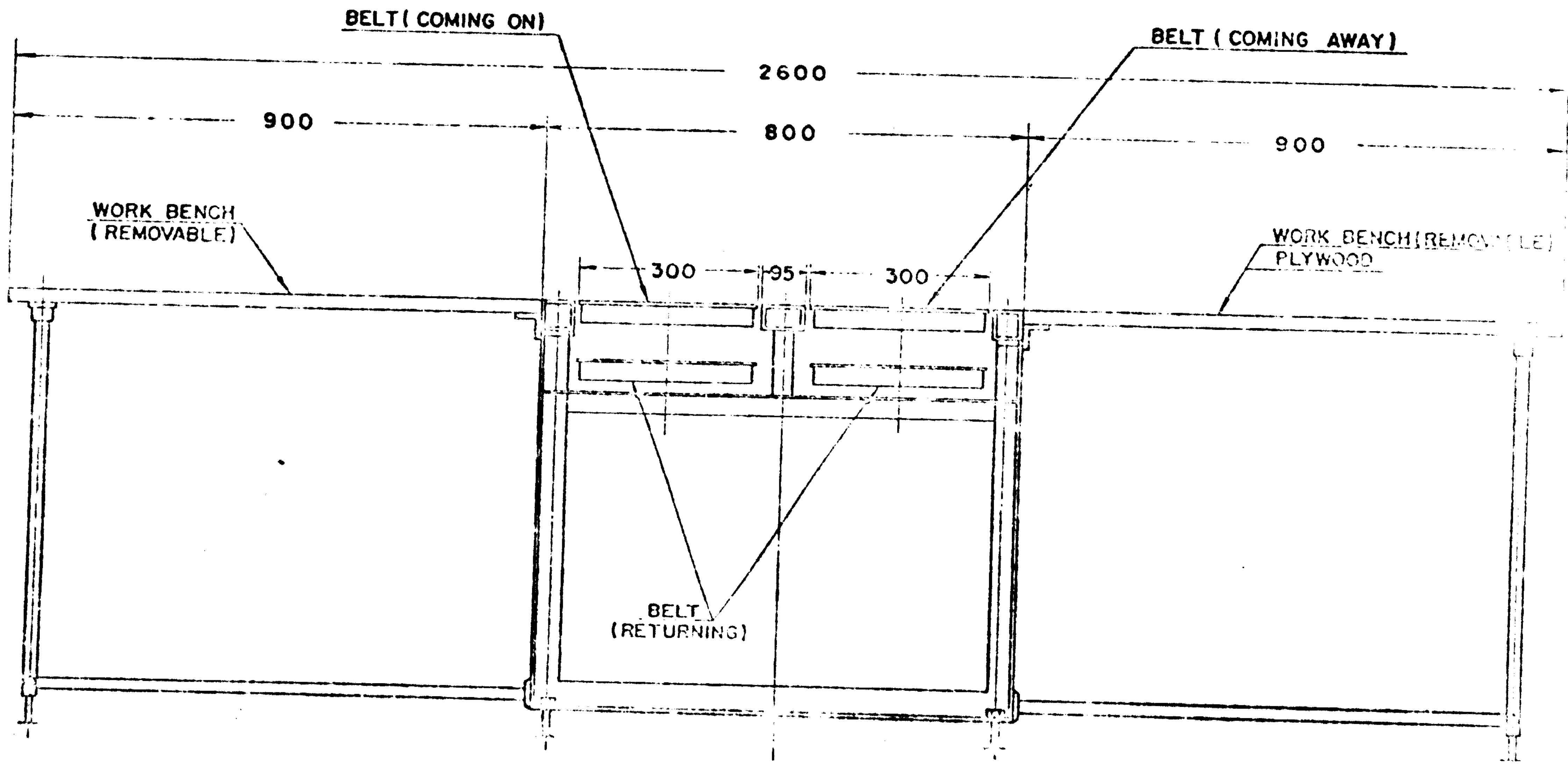


Table 1 Brief Specifications of Measuring Instruments

| ITEM NO. | CATEGORY | SPECIFICATIONS |
|---|---|---|
| 1 | Signal Injector (Pulse Generator) | Frequency : 200Hz<br>Output : 1 - 2V peak<br>Pulse width : 0.01 - 0.02msec. |
| 2 | CRT Oscilloscope | CRT: : 5 inch<br>Sensitivity :<br>V -- 1mV/cm<br>H -- . 10mV/cm<br>Ext -- P-P 40mV/cm |
| 3 | V.T.V.M. | Freq. range : 30Hz - 200kHz<br>Sensitivity : 0.01mV - 100V at input imp. of 500k ohm |
| 4 | RF V.T.V.M | Freq. range : 100Hz - 300MHz<br>Voltage range: 1mV - 10V<br>Input impedance : Less than 5PF. |
| 5 | Stabilized DC power Supply | Output : 0 - 25V, ±2%<br>0 - 2A |

| | | | | |
|---|---|---|---|---|
| 6 | Ohmmeter<br>or<br>Voltohmist | R range | : | Up to 1MΩ |
| | | V range | : | Up to 100V (100kΩ/V) |
| | | A range | : | Up to 1A |
| 7 | VHF FM<br>Signal<br>Generator | Freq. range | : | 9.7 - 11.7MHz<br>53 - 131MHz |
| | | Output | : | 0.3μV - 0.1V<br>Z = 75Ω or 50Ω |
| | | Modulation | : | FM -- 0 - 100kHz Dev.<br>AM -- 0 - 30% |
| | | Mod. Freq. | : | 400Hz & 1000Hz |
| 8 | AM signal<br>Generator | Freq. range | : | 100kHz - 30MHz |
| | | Output | : | 1μV - 1V<br>Flat within ±1dB |
| | | Modulation | : | 0 - 100% |
| | | Mod. Freq. | : | 400Hz, 1000Hz |
| | | Including Test loop | | |
| 9 | Distortion<br>Meter | Freq. range | : | 20Hz - 100kHz |
| | | Distortion range | : | 0.1% - 30% |
| | | Level | : | 0.3mV - 10V |
| 10 | Test Loop | Freq. range | : | 400kHz - 30MHz |
| | | Loop diam | : | 250mm |
| | | Cable Length | : | 1.2m |

| | | |
|---|---|---|
| 11 | 455kHz Sweep Generator | Center freq. : 400 - 500kHz<br>Sweep : 0 - ±50kHz<br>Marker : 445, 450, 455, 460 & 465kHz<br>Sweep rate : 1/2 of line freq.<br>Output control: 100μV - 0.1V |
| 12 | 10.7MHz Sweep Generator | Center freq. : 9.5 - 11.5MHz<br>Sweep : 0 - ±500kHz<br>Marker freq. : 10.55, 10.625, 10.7, 10.775, & 10.85MHz<br>Repetition rate: 1/2 of line freq.<br>Output control: 100μV - 0.1V |
| 13 | Shield Room No. 1 | Frequency : 400kHz - 200MHz<br>Attenuation : 60dB<br>Dimensions : 180 D x 180 W x 180 H (cm) |
| 14 | Shield Room No. 2 | Frequency : 400kHz - 200MHz<br>Attenuation : 100dB<br>Dimensions : 180 D x 360 W x 270 H (cm) |

Table 2. Number of Test Instruments Required for the production of Radio Receivers of 10,000 Sets Monthly

| Test Item No. | Instrument(1) Category | No. of T.I. Required Type'A' Rec | Type'B' Rec | Type'C' Rec | Laboratory(2) |
|---|---|---|---|---|---|
| 1 | Sig. Injector | 8 | 10 | 8 | 1 |
| 2 | Oscilloscope | 6 | 9 | 6 | 1 |
| 3 | V.T.V.M. | 5 | 8 | 5 | 1 |
| 4 | RF V.T.V.M. | | | | 1 |
| 5 | Power Supply | 9 | 11 | 9 | 1 |
| 6 | Voltohmist | 4 | 5 | 4 | 1 |
| 7 | VHF FM Sig.Gen. | | | 5 | 1 |
| 8 | AM Sig. Gen. | 5 | 8 | | 1 |
| 9 | Distortion Meter | 3 | 3 | 3 | 1 |
| 10 | Test Loop | 5 | 8 | | 1 |
| 11 | 455 Sweep Gen. | 4 | 5 | | 1 |
| 12 | 10.7 Sweep Gen. | | | 4 | 1 |
| 13 | Shield Room | | | | 1 |
| | Type 1 | | | | 1 |
| 14 | ditto Type 2 | 2 | 4 | 2 | 1 |

Note (1) As to specifications, see Table 1

(2) Minimum Installation at laboratory.

## 6. TRAINING OF ENGINEERS AND WORKERS

Each engineers' or technicians' degree of personal skill and expert knowledge in manufacturing radios throughout the factory's various sections--as well as its production facilities--are main factors governing the effectiveness of producing low-cost radio receivers. If experienced engineers or technicians are not available for producing low-cost radio receivers in countries undergoing development, instruction and/or training for the applicable personnel is a prime requisite. Two ways deemed appropriate for quick, effective training for such personnel are: (1) receiving instruction at an qualified radio manufacturer's plant in a developed industrial nation, dispatching several promising personnel; or on the contrary, (2) receiving instructions in their own country from experienced, capable instructors dispatched from a developed industrial nation. It is advisable to give ample consideration to avoiding troubles which may arise as a result of differing living habits in both countries concerned: otherwise, the anticipated adequate results of instruction may not materialize.

Technicians required for producing radio receivers are roughly classified into design engineers, production engineers, and quality control engineers. Each technician requires certain specialized instruction and training depending on their own job at the radio factory. Workers engaged in the workshop also require certain technical training.

The design engineers--both circuit designers and cabinet designers--require the longest instruction period. For those freshly graduated from electronics, mechanical, or industrial design courses of technical colleges or universities, several years' practice at an appropriate works in a developed industrial nation may be necessary to become full-fledged design engineers. Circuit design engineers must be thoroughly familiar with the fundamental theory of radio receiver circuits, characteristics of various materials and electronic components and production technology, quality control techniques, and value analysis. Cabinet design engineers require an inherent sense of art, a knowledge of production technology, mechanical engineering, quality control, and value analysis.

The production engineer prepares assembling guidance and supervises factory operations, constantly reviewing production line conditions. If he uncovers certain discrepancies caused by design defects, he must feed back the information to the design section. He must cultivate a wide range of knowledge covering not only production technology but also the newest electronic circuits and quality control.

Technicians requiring special training are those engaged in repairing rejected works from the production line and intermediate or final testing. Especially, during the early days of producing a new model, these jobs may be demanded of technicians very frequently. Their important task is to trace the cause of malassembly and to quickly eliminate the source by thoroughly explaining to the line chief. The quality control engineer, responsible for product final quality manufactured at the works, naturally controls the quality of the components purchased. Low-cost components are liable to cause defective products. The QC engineer is forced to make decisions on accepting or rejecting from the standpoint of the enterprise, and at the same time, the user's point of view. He must have a general knowledge of quality control and is required to be familiar with a wide range of knowledge similar to the design engineer.

Additionally, technicians employed as chiefs of production lines, including aligning and testing, require to some extent instruction and training similar to engineers.

Workers engaged in soldering operations on the production line also require special training. The degree of firmness of soldered joints in radio receivers exerts a great influence on product reliability. In some cases, imperfectly connected joints soldered by unskilled workers may account for 70 to 80% of all defective work.

For the purpose of to bring up level of technology of concerned personnel, it will be effective to have occasional meetings of groups to discuss on their daily jobs, The items of discussion may be problems in trouble met or method of improvement of their working.

## 7. MANUFACTURING

When initiating the mass production of radio receivers at a factory, its rational organization and operation must have been previously established.

As an example, a simple organization and its operation are exemplified and discussed in this chapter.

For example, under control of the factory manager, each section dealing with design, production technique, purchasing, manufacturing, and quality control are established.

On receiving finalized drawings complete with parts listings and specifications, the Production Technique Section starts trial production of about ten sets, intent on thoroughly examining accuracy of the original design and productivity of the designed product from every angle.

At this stage, value analysis technique may be applied. The Production Technique Section informs the Design Section as soon as possible of the examination results, especially highlighting defective design points with the aim of revising the original design. The section prepares a detailed production schedule by making an analysis of the manufacturing process, and issues working instructions for the other sections concerned. Details of the above procedure are discussed in Addendum 1 to this document.

The Purchasing Section procures materials and components required for production conforming to the production schedule in accordance with revised final drawings and parts listings with specifications. The receipt of each item purchased must be strictly in time for the planned schedule; otherwise, confusion may result on the production line. The most important target for this section is purchasing necessary materials and components at the lowest possible cost for the required specifications, and to ensure supplying all items on schedule.

The Manufacturing Section assembles necessary workers, instruments and tools for meeting the production schedule. In the first step of mass-producing a newly designed receiver, several tens of preproduction sets are assembled on the normal production line belt conveyor to effect a uniform examination of product performance and to check the accuracy of manufacturing instructions. This examination may be conducted under cooperation of the Production Technique Section. Should any defects be discovered in the preproduction stage, the necessary revisions must be made. This preproduction procedure also serves as excellent on-the-job training for all personnel concerned.

A thorough examination of trial products and preproducts are important preparatory steps in the mass production system. Most malfunctions and bottle-necks occurring on the production line may be contributed to insufficient examination during the above-mentioned procedures together with a delay of receiving materials and components.

After completing the examination and making the necessary revisions, normal mass production is started.

The Quality Control Section is responsible for the performance of factory products together with the materials and components supplied to the works. This section conducts examinations on received materials and components in accordance with established quality control techniques. Final inspections of completed products may be conducted through cooperation with the section concerned.

Details of the above-described procedures are discussed in Addendum 1 to this document.

8. GUARANTEE & AFTER-SALES SERVICE

Guarantee against product defects and the attitude toward after-sales service become the responsibility of individual manufacturers in proving themselves worthy of maintaining customer reliance. The term of guarantee should be reviewed from the standpoint of reliability and product cost, the manufacturer assuming the responsibility for repairing product defects without charge within the terms of guarantee (except where caused by the user's careless handling). Generally, the term of guarantee should not be less than one year for common radio receivers, based on conventional commercial custom.

The reliability of radio receivers depends upon the technique of quality control, and in turn, manufacturing workmanship including performance of the components used. Design technique may also be responsible for reliability under certain circumstances.

It is advisable to constantly keep an eye on the defects of receivers sold to customers, and to pass on these results to the design and manufacturing sections--this applies especially to those very young in the business.

Expenses incurred in repairing defective products during the guarantee term must be included in product.cost. The amount of repair expenses may be estimated statistically, based on actual market results and factory quality control data. Generally, around one percent of product factory cost may be taken into account as expense incurred for guarantee.

Most product troubles arising during the guarantee term are usually minor ones, easily repaired by ordinary service technicians (except bad defects due to design and/or manufacturing technique).

If skilled service technicians are not available at dealer or distributor shops, manufacturers must implement a repair group to effect centralized repair work. This group must be independent of the design section and production line. These service technicians require special skill in dealing with repairs neatly and quickly.

Regarding after-sales service, replacement parts for all receiver models--including those discontinued--must always be kept in stock at the repair station. Generally, replacement parts totaling about one percent of the total number of shipped products proves adequate.

Repair stations must be equipped with test instruments such as voltmeters, ohmmeters, audio oscillators, RF test oscillators, and cathode-ray oscilloscope equipment.

7. 7. 72