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Small-Scale Manufacturing Studies No. 1

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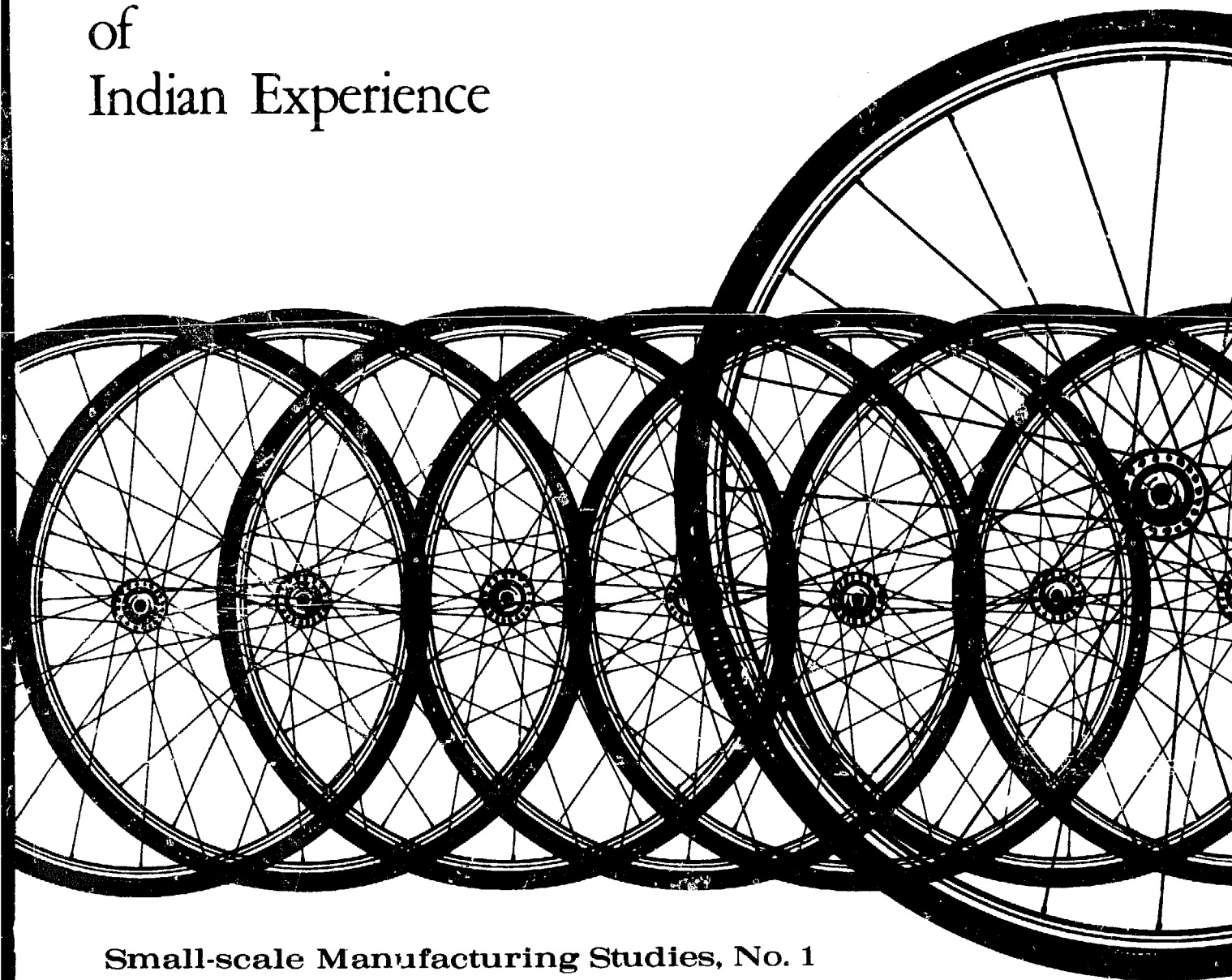
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BICYCLES

A Case Study
of
Indian Experience



Small-scale Manufacturing Studies, No. 1



UNITED NATIONS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

SMALL-SCALE MANUFACTURING STUDIES, No. 1

BICYCLES

A Case Study of Indian Experience



UNITED NATIONS
New York, 1969

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FOREWORD

This publication is the first in a series on the contribution of small-scale industries to the production of consumer goods and producer goods of special importance to the development of industrializing countries.

It is commonly believed that, because of the handicap of size and consequent diseconomies of scale, and because of frequent weaknesses in technology and management, small-scale industries in the developing countries should not be oriented towards the manufacture of goods which benefit from mass production or call for complex technologies—automatic or specialized machinery, involved processes, high-precision work, etc. It is sometimes argued that small-scale industries in the developing countries should be confined to the production of simple goods requiring simple technologies. Small-scale industry is considered as intermediate between the traditional sector of artisans and handicrafts and the modern manufacturing sector—closer to the former than to the latter.

In fact, small-scale industries are or can be thoroughly modern—through the use of modern machinery, up-to-date processing and management techniques, and the production of modern and sophisticated goods.

No individual small-scale enterprise should attempt to produce the well-known items requiring large-scale plant and mass production—automobiles, airplanes, ships, steel and many others. However, many small-scale industries may—and, principally in industrial countries, do—contribute to the production of some of these goods under subcontracting arrangements whereby they manufacture parts and components or undertake certain processing and finishing operations for large-scale industries.

In any economy, a large number of items are or can be economically produced either in the large- or small-scale sectors. This is true of bicycles, motorcycles, electronic and optical goods, some machine tools, certain types of agricultural, electrical and other machinery and a number of home appliances. In large-scale industries, especially in some industrializing countries, most of the parts and components are usually manufactured in the plant itself and costs are kept low through mass production. In small-scale industries, some (and occasionally all) of the components are made in the plant, and the others are bought from large-scale manufacturers, from specialized small-scale producers, or from importers. Costs are reduced through low overhead, appropriate machinery, the use of labour-intensive operations and simplification of processing techniques.

Thus, the goods under consideration may be produced under several alternative arrangements: (a) entirely by a large-scale industry; (b) assembled by a small-scale industry that may manufacture some of the parts and components or even the whole item; (c) under subcontracting arrangements between the large-scale factory and a number of small-scale ones; (d) under subcontracting arrangements among small-scale industries; and (e) under a new and largely

untested system, sometimes called "functional organization", whereby a number of small-scale producers manufacture and assemble parts and components of a given item according to a common production programme.

The question whether there is scope for one, several or all of these arrangements in any given country will vary according to the circumstances. In some countries, large-scale production, and therefore subcontracting between large- and small-scale industries cannot be justified economically. Elsewhere, the inadequacy of skills, and the obstacles to joint or co-operative undertakings, may hamper the promotion of subcontracting or of functional programmes among small-scale enterprises. In far too many cases, the lack or inadequacy of industrial extension services and of financial assistance may prevent small-scale industries from contributing under any arrangement to the production of major consumer goods or producer goods.

There are strong grounds for believing that, provided an integrated programme of promotion of, and service to, small-scale industries is in operation, one or several of the above forms of organization can be introduced or expanded in most developing countries. In order to produce or to contribute to the production of the goods in question, small-scale industries should have well-trained workers, should be adequately financed, well equipped, well managed, able and willing to co-operate, and, not infrequently, highly specialized. As a rule, this can be achieved only if the industry is assisted at all stages of establishment, management and operation through a comprehensive system of measures including: technical and managerial counselling; training; financing on liberal conditions; industrial estates, including sometimes functional or ancillary estates; common service facilities and a variety of incentives and measures of protection.

This series of publications, of which the present study on bicycles is the first, is aimed at facilitating the establishment or expansion of the above forms of organization in the developing countries. It is predicated on the assumption that, in the production of certain types of important goods, the small-scale industry sector can be complementary to, or competitive with, the large-scale industry sector, or can substitute for it where it does not or cannot exist. Since the contribution of small-scale industries may range from the production of a few parts to the manufacturing of a whole product, each study should contain a detailed analysis of the type, design and specification of all parts and components of the selected product. Since even the most modern small-scale industries have limitations owing to size and scale of operation, each study should describe appropriate machinery, propose simplifying innovations in processing, and point out labour-intensive operations—without, however, affecting productivity and product quality. Data should also be provided on manufacturing processes in the large- and small-scale sectors; on the operations that lend themselves to subcontracting and joint production programmes; on standards, quality control and inspection procedures; on internal and foreign marketing; and on productivity and costs in the large- and small-scale sectors.

The treatment of the subject in this study goes far beyond what is usually found in "model schemes" or "industry profiles". While the study is based almost entirely on the experience in India, it is likely that most of its findings

and recommendations are applicable to the conditions prevailing in other developing countries. The study is intended for officers of industrial extension centres, small-scale industry service institutes, industry departments of ministries of industry, technological research institutes, technicians of industrial credit institutions, large- and small-scale industrial entrepreneurs, and technical assistance experts in developing countries.

The subject of bicycles was selected for the first issue of this series because bicycles can be produced under various arrangements, and because of the widespread demand for bicycles throughout the developing world. Other studies to be published in this series will deal with sewing machines, radios, domestic electrical appliances, agricultural implements and several types of machine. UNIDO does not intend, however, to cover all possible items of small-scale manufacture, and there is much scope for research to be undertaken by other organizations along these lines, mainly in relatively advanced developing countries. It is hoped that the studies in the present series will encourage further efforts. Co-ordination of the research to be undertaken by other organizations with the work programme of UNIDO is invited.

The study was prepared by G. B. Jakheta, Deputy Director, Central Small Industries Organisation of the Ministry of Industrial Development and Company Affairs, Government of India, and by R. Lakshminarasimhaiah, Deputy Director in the same organization, in their capacity as consultants to UNIDO. The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the secretariat of UNIDO.

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ABBREVIATIONS AND NOTES

The following abbreviations are used in this paper:

BB	bottom bracket
BSS (or BS)	British Standard Specification
BSW	British Standard Whitworth
CRCA	cold-rolled coil annealed
cwt	hundredweight (50.802 kg)
DC	direct current
dia.	diameter
EN	Emergency National (British Standards)
ERW	electrical resistance welded
ft	foot or feet
G.	gauge
HB	hard-drawn bright (wire)
hp	horsepower
h	hour
HV	hardness (Vickers)
ID	inside diameter
in.	inch or inches
ISI	Indian Standards Institution
ISS (IS)	Indian Standards Specification
kg	kilogramme
kW	kilowatt
LH	left hand
mm	millimetre
MS	mild steel
OD	outside diameter
RH	right hand
rpm	revolution per minute
Rs.	rupees (7.50 rupees = US\$1.00, 1969)
TPI	thread per inch

Gallons referred to in the text are imperial gallons of 4.546 litres.
"Ancillary industrial unit" is defined on page 63.

INTRODUCTION AND DEVELOPMENT OF THE MODERN BICYCLE IN INDIA

The pedal-driven bicycle, which was the first attempt of man to provide himself with a personal mode of transport without using animal power, was invented in 1839 by Kirkpatrick Macmillan of Scotland. The "velocipede", as the bicycle was originally called, has undergone many changes in its design, and its manufacture has developed greatly during the past hundred years. Thus the modern bicycle is a mechanized marvel on two wheels and a product of specialized technical achievement.

Utility and place of the bicycle in the economy

The bicycle is a cheap and speedy means of personal conveyance. Although it is operated by one's own power, it is four times as fast as walking and demands far less energy. It plays an important role in daily life; it is able to carry loads many times its own weight, and is used as a carrier by grocers, bakers, milkmen, newspaper boys and the like. In many advanced countries holiday cycling is a national pastime and there are many who enjoy bicycle racing as a sport. The bicycle is a useful conveyance in almost all countries, but it plays an especially significant role in the economy of India, as it is the most suitable and perhaps the cheapest mode of conveyance in rural and urban areas.

Bicycle manufacture requires not only special skills in tool making, design of press tools, jigs and fixtures, but also high-quality raw materials such as cold-rolled steel strips or coils, ERW bicycle tubes, high carbon steel wire, rubber moulded goods and enamels and paints.

Development of the bicycle industry in India

The bicycle industry has a significant place in the light engineering industry in India. The origin of this industry dates back to the early years of this century. It is reported that two small-scale units were established in Calcutta in 1910. The industry, however, did not make much headway initially and India continued to be a flourishing market for foreign bicycles. The development of the industry started during the Second World War when the import of bicycles became difficult. A few enterprising industrialists took advantage of this situation and started the manufacture of bicycles and components. In 1941 a large-scale unit was set up in Bombay; in the Punjab a few units started the manufacture of bicycle parts and accessories for the replacement market.

Systematic growth of the bicycle industry began only after the independence of India with the beginning of the planning era. Between 1950 and 1960 many

units were established in both the large- and small-scale sectors, owing to various measures of protection and incentives granted to the indigenous manufacturers by the Government. Another favourable factor responsible for the growth of this industry was the increase in demand for bicycles consequent to the establishment of industrial townships, the construction of roads in the urban and even remote rural areas, the increase in trade between small villages and towns and the rise in the standard of living of the people under the impact of successive five-year plans.

Growth in the small-scale sector

The planned growth of the bicycle industry in the small-scale sector started immediately after the introduction of the common production programme by the Government of India during the First Five-Year Plan. The common production programme envisaged the reservation of specific capacities for the manufacture of bicycles in the small-scale sector by putting a check on the expansion of the existing capacities in the large-scale sector and also by giving priority to industries in this programme for various important inputs such as raw materials, components and technical and financial assistance. Following these incentives, manufacturing programmes for several small-scale units were approved by the Government of India for the manufacture of components and complete bicycles.

To give some protection to the indigenous bicycle manufacturers, the Government adopted a policy of progressive reduction of imports. This has helped the indigenous manufacturers to eliminate competition from foreign manufacturers and to meet the demand for bicycles by producing them within the country. Until 1957 the import of complete bicycles was allowed. Thereafter, only the import of raw materials and components was allowed, and this on a selective basis, particularly with respect to those items for which manufacturing capacity had not been fully developed within the country. This policy made it possible for small-scale industrialists to assemble complete bicycles at a lower capital investment by manufacturing only a few parts in their factories. Gradually the manufacture of the components that had been imported was started. The raw materials, however, continued to be imported. With the overall increase in the production of bicycles and components, the raw materials needed by the industries also began to be produced in the country.

The bicycle industry in the small-scale sector developed mainly on the following lines: (a) units specializing in the manufacture of specialized components such as free-wheels, rims, mudguards, hubs, spokes and nipples and BB shells; and (b) assemblers manufacturing a few parts and obtaining other components from units that specialize in their manufacture.

Contribution of small-scale industries

Small-scale industries have made a substantial contribution to bicycle production in India. Table 1 indicates the number and type of units (small- or large-scale), their installed capacity and actual production. The table shows the progress made by the bicycle industry in India during the period 1962–1966.

Table 1

INSTALLED CAPACITY AND ACTUAL PRODUCTION OF BICYCLE
MANUFACTURING UNITS IN INDIA, 1962-1966^a

Year	Large-scale sector			Small-scale sector		
	No. of units	Installed capacity	Production (thousands of bicycles per year)	No. of units	Installed capacity	Production (thousands of bicycles per year)
1962	21	1,444	1,116	55	508	178
1963	21	1,444	1,166	50	610	274
1964	20	1,640	1,380	50	610	308
1965	20	1,640	1,540	50	610	308 ^a
1966	18	1,640	1,631	48	610	308 ^a

^a Estimates.

It may be seen that the small-scale sector accounts for about 20 per cent of the total production of bicycles in India. Moreover, a large number of small-scale units have been contributing substantially towards the manufacture of bicycle parts, components and accessories. Small-scale manufacturers are manufacturing highly sophisticated parts such as chains, spokes, free-wheels, hubs, chain wheels and cranks. Some large-scale manufacturers are now buying these components from small-scale units. Such co-operation has created a healthy ancillary relationship between the large- and small-scale manufacturers and has resulted in economies of production and over-all improvement in the quality of bicycles. This has made it possible for the bicycle industry to break well into the export market, and the bicycle is now one of the light engineering items being exported by India.

Future potential

It is anticipated that by 1970/1971 there will be a yearly demand for 3 million bicycles in India compared to the present production of 2.25 million per year. The industry, therefore, has good scope for expansion, which can be realized only by enhancing the existing capacities or encouraging the establishment of new units. Recognizing this fact, the Government of India has declared, under the Industries Development and Regulation Act, that no industrial licenses will be required, even to set up large-scale units. Owing to the confidence created by the small-scale units, the Government has reserved manufacture of all parts and components except a few specialized items, such as free-wheels, rims and chains, for the small-scale sector. The bicycle industry has also been declared a priority industry and the manufacturers of bicycles and bicycle parts are therefore assured a full supply of raw materials, from imported sources if necessary. These measures taken by the Government of India obviously offer a great opportunity for further development of this industry in the small-scale sector.

TYPES, DESIGNS AND SPECIFICATIONS OF BICYCLES MANUFACTURED IN INDIA AND OTHER COUNTRIES

TYPES

The type of bicycle manufactured depends upon the user for whom it is intended and the purpose for which it is to be used. The rider may be a man, woman or child; the purpose may be for sport, racing or load-carrying. Recently some unconventional types have been made such as portable folding, small-wheeled and cantilever models.

Bicycles produced in India

The following types of bicycle are manufactured in India:

- (a) Men's roadster, single bar model, with raised handle-bar and double levers;
- (b) Men's roadster model with double bar;
- (c) Women's model with curved tube;
- (d) Women's model with straight tube;
- (e) Sports model with raised handle-bar and caliper brakes;
- (f) Children's model.

Bicycles produced in other countries

In Japan several types of bicycle are produced in addition to those made in India; they are:

- (a) Racer model with ten-speed dérailleur gear;
- (b) Men's light-weight model;
- (c) Low gravity carrier;
- (d) Small-wheeled cantilever model;
- (e) Portable folding model.

Most of the types described above are manufactured in the United Kingdom and other European countries, the most popular types being sports and racing models.

Recently a new type, called the Moulton bicycle, has been introduced in the United Kingdom. This bicycle has changed the concept of pedal bicycles that has prevailed since the introduction of the two-wheeled safety bicycle in 1885. The novel features of the Moulton bicycle are: small wheels of 16 in. diameter; natural rubber suspension system; large luggage rack at front and rear; precision built frame of special section steel tube; and low centre of gravity. A folding model called the Moulton stowaway has also been introduced.

Raleigh Industries Ltd, England, has developed a small-wheeled bicycle with the additional feature of adjustable handle-bars to suit all riders from children to adults. In Hungary also, collapsible, foldable and detachable models have been developed. The special feature of these bicycles is that they can be folded and stored even in the boot of a car and can be quickly assembled within two to three minutes.

DESIGNS

Bicycle designs vary according to the shape and style of their components. Different designs may be used for mudguards, pedals, frames, cranks and chain wheels.

Typical examples of various designs used in the manufacture of certain parts are given below.

<i>Frames</i>	Sports; men's roadster; women's sports, women's roadster; men's double bar
<i>Forks</i>	Tubular crown with chromium plated brass thimbles; flat crown with brass cover chromium plated; butted column with tubular crown chromium plated thimbles; butted column with brass crown cover chromium plated
<i>Mudguards</i>	Deep round section; deep domed section; ribbed section; U-shaped section; round narrow section
<i>Cranks and chain wheel</i>	Joggled with cranks square or oval section; cranks with double chain wheels; joggled with detachable arm
<i>Handle-bars</i>	Raised with double lever screwing stud attachment; raised with double lever brazed lever stud; north road raised pattern; raised without lever with T-jointed stem; dropped for sports and racer models
<i>Brakes</i>	Lever brakes with brake shoes; caliper brakes with side pull or central pull system
<i>Hubs</i>	Thin barrels closed ends; thin barrels closed ends with replaceable dust caps or open ends; large barrels closed ends of pressed steel; curved barrels with open ends; thin barrels closed ends for dérailleur gears
<i>Saddles</i>	Men's full roadster three-coil springs and double wire base; women's roadster with turned down nose, heavy-weight double wire base with double loop front and rear; spring seats double wire base and rear coil springs
<i>Pedals</i>	Pyramid full rubbers with screwed dust cap or winged dust cap; diamond full rubbers with screwed or winged dust caps; rat-trap type for sports and racers; full plastic pedals ¹

¹ A fully plastic pedal has been developed in India in which the 94 conventional parts in a pair of pedals have been replaced by only seven plastic parts for each pedal without sacrificing functional efficiency.

<i>Chain guard</i>	Full double-sided; single-sided or half chain covers; quarter chain cover
<i>Luggage carriers</i>	Tubular construction; pressed steel frames provided with grip or simple straps
<i>Bells</i>	Lever operated electric bells or siren horns; spoke bells operated by caliper handle-bar.

SPECIFICATIONS

Bicycles produced in India

The sizes of bicycles produced in India are 20 in., 22 in., and 24 in., men's and women's models. The children's models are made in 14 in., 16 in., and 18 in. sizes.

The men's roadster model, single bar (figure 1) is the most popular bicycle in India. The specification of this bicycle is given in chapter 3.

The specification of a sports model is: 21 in. frame; 26 in. \times $1\frac{3}{8}$ in. wheels; raised handle-bar; adjustable stem assembly; caliper brakes; Westrick rims with $\frac{1}{4}$ in. chain cover; and suitable saddle.

Bicycles made in Japan

The specifications of a few types of bicycle produced in Japan are given below.

(a) *Racer with ten-speeds*

<i>Frame</i>	21 in. \times 27 in. \times $1\frac{1}{4}$ in.; built of best quality high-tension steel tubing; brazed up lugs; front fork model for racer; any colour on request; handle-bar stem locking ring with micro-adjuster
<i>Wheels</i>	Rims: 27 in. \times $1\frac{1}{4}$ in., flat-sided, wired on, chromium plated, 36 \times 36 holes Tires: 27 in. \times $1\frac{1}{4}$ in., wired-on, black tread and side walls Tubes: butyl tubes with English pattern valves Spokes: steel spokes, 15 G., plated Hubs: best forged steel hubs Dérailleur gear: ten-speed gear with $\frac{1}{2}$ in. \times $\frac{3}{32}$ in. \times 15, 17, 19, 21 and 24 teeth multiple free-wheel
<i>Handle-bar</i>	Dropped, deep-curved, chromium plated, black handle tape with cap ends, extended stem
<i>Brakes</i>	Calipers, front and rear, light alloy levers and arms chromium plated, quick release
<i>Gear and cranks</i>	$\frac{1}{2}$ in. \times $\frac{3}{32}$ in. \times 47 and 50 teeth double chain wheels
<i>Chain</i>	$\frac{1}{2}$ in. \times $\frac{3}{32}$ in. \times 114 links
<i>Pedals</i>	Rat-trap design
<i>Saddle</i>	Plastic

Accessories and equipment Bell, light alloy frame pump, toe clip and side reflector

(b) *Cantilever type*

Frame 14 in. × 20 in. × 1³/₄ in., American type, flamboyant red finish with white head decoration and lines, other colour finish to order

Wheels Rims: model 7 A, 20 in. × 1³/₄ in., wired-on, 24 × 24 holes
Tires: 20 in. × 1³/₄ in., black tread and white sidewall, wired-on
Tubes: butyl seamless tubes with American pattern valves
Spokes: 14 G. plated
Hubs: front, 24 holes with ball retainers; rear, coaster hub brake
1/2 in. × 1/8 in. × 16 teeth sprocket

Handle-bar Boyscout 16¹/₂ in. bar with model Y stem (adjustable)

Brakes Rear, coaster hub brake

Mudguards Chromium plated, channel stays front 2-piece; rear 1-piece, with reflector

Gear and cranks 1/2 in. × 1/8 in. × 32 teeth, 5 in. oval-section cranks

Chain 1/2 in. × 1/8 in. × 82 links

Pedals 3¹/₄ in. white rubber blocks

Saddle Pan type, two-tone vinyl top with spring

Accessories and equipment Battery lamp, rear carrier and stabilizers

(c) *Sports model*

Frame 21 in. × 26 in. × 1³/₈ in.; built of best quality steel tubing; brazed up lugs and cottorless bracket; straight tapered seat and chain stays brazed up; pump pegs; front fork with plated crown cover; flamboyant red with gold line

Wheels Rims: model 5, 26 in. × 1³/₈ in., 36 × 36 holes, chromium plated
Tires: 26 in. × 1³/₈ in., wired-on, white sidewalls
Tubes: seamless butyl with American pattern valves
Spokes: 15 G., plated
Hubs: thin barrel front hub; 3-speed gear hub with handle grip control for rear; 1/2 in. × 1/8 in. × 18 teeth sprocket

Handle-bar North road pattern, with 1 in. extension stem

Brakes Calipers, front and rear chromium plated

Mudguards Light-weight model chromium plated

Gear and cranks 1/2 in. × 1/8 in. × 46 teeth, with 6¹/₂ in. square-section cranks

Chain 1/2 in. × 1/8 in. best roller chain

Pedals 4 in. white rubber

Saddle Spring seat, imitation leather top, two-tone colour

Accessories and equipment Rubber reflector, battery light, touring bag, centre stand, chain cover, frame pump and front carrier

SPECIFICATION OF THE BICYCLE SELECTED FOR THIS STUDY

The men's roadster, single-bar, is the most popular bicycle in India and in most of the developing countries in the Middle East. It is popular because of its strong construction and it meets the requirements of countries where the roads are poor. The roadster, therefore, has been selected for this study. (See figure 1.)

- Frame** 24 in. men's roadster model manufactured to IS 623; tubes electric resistance welded to IS 2484 and IS 2039; seat tube $1\frac{1}{8}$ in. dia. \times 20 G.; down tubes 1 in. dia. \times 18 G.; top tube 1 in. dia. \times 20 G.; head tube $1\frac{1}{4}$ in. dia. \times 20 G.; tubes are provided with internal liners made from 16 G. MS sheet; lugs are made from annealed 16 G. MS sheets; bottom bracket shell of malleable cast iron, made to BS 309 and IS 2107; lugs and BB shell are pinned and brazed with the tubes
- Fork** Made to IS 2061; fork blades tapered and oval made from ERW tapered tube to IS 2484 and IS 2039; fork column either butted or provided with liners made from 16 G. MS sheet; fork crown pressed from 16 G. CRCA sheet; crown cover pressed from brass sheet 22 G., nickel and chromium plated
- Wheels** Rims: made to IS 624; size 28 in. \times $1\frac{1}{2}$ in., manufactured from CRCA strip
Spokes and nipples: made to IS 630; spokes made from 1.8 mm dia. high carbon steel wire; and nipples from free cutting extruded brass of 3.8 mm dia.; nickel and chromium plated
Tires: size 28 in. \times $1\frac{1}{2}$ in., wired-on, black tread
Tubes: made to IS 2415; size 28 in. \times $1\frac{1}{2}$ in., butyl rubber, seamless, with English pattern valves and plate washer, made to IS 532
Hubs: made to IS 629; large barrel of seamless tube $1\frac{1}{16}$ in. \times 16 G.; closed ends made from pressed steel 14 G. CRCA sheet; front hub axle $\frac{5}{16}$ in. dia. \times $4\frac{1}{2}$ in., made from bright steel bar; rear hub axle $\frac{3}{8}$ in. dia. \times $6\frac{1}{2}$ in., made from bright steel bar; cones made from ENIA steel $1\frac{1}{16}$ in. dia., case hardened to 600 HV and chemically rust-proofed or blued; steel balls $\frac{1}{4}$ in. chromium alloy steel, made to IS 2898

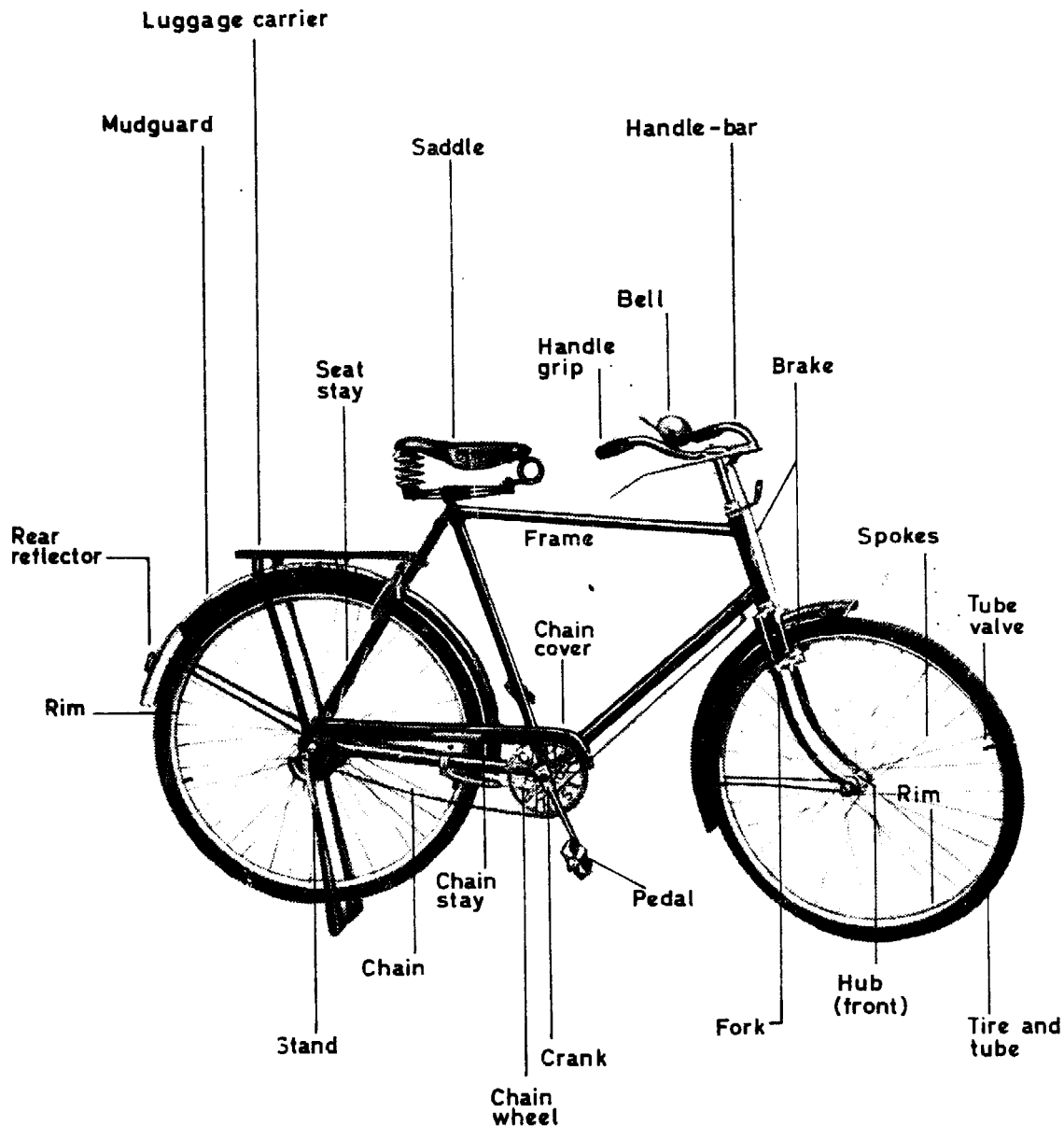


Figure 1. Men's roadster, single-bar, bicycle

Handle-bar Made to IS 625, roadster raised pattern; handle-bar ERW bicycle tube $\frac{7}{8}$ in. dia. \times 16 G., made to IS 2434 and IS 2039; handle-bar with eye bolts made from 15 mm dia. MS; and double lever (for brakes) made from 10 mm dia. MS; nickel and chromium plated with celluloid grips

Brake sets Lever rim brakes front and rear for 24 in. frame; front and rear brake stirrups with tube $\frac{3}{32}$ in. ID MS L-shaped bell crank levers made from 14 G. MS sheet; bottom long brake rod made from 9 G. HB wire; brake shoes made of 18 G. CRCA sheet and assembled with brake block of moulded rubber; all metal parts nickel and chromium plated

- Mudguards** Deep dome section $2\frac{1}{4}$ in. wide \times $1\frac{1}{32}$ in. high suitable for 24 in. roadster, made from 24 G. CRCA strip or sheet; with stays made from $\frac{3}{16}$ in. dia. MS rod; black enamel finish and gold lined; rear mudguard tail painted white and fitted with reflector
- Chain wheel and cranks** Made to IS 1281; jogged chain wheel made from MS sheet 3 mm 48 teeth \times $\frac{1}{2}$ in. pitch; cranks of forged steel, 7 in. long in oval section; nickel and chromium plated
- Chain** Made to IS 627; $\frac{1}{2}$ in. pitch \times $\frac{1}{8}$ in., 112 links; inner and outer plates made from cold-rolled bright steel strip 1 mm thick and blued; bushes and rollers heat treated to 600 HV; spring clip type connecting link made from 1 mm spring steel
- Free-wheel** Made to IS 1283; size $\frac{1}{2}$ in. pitch \times $\frac{1}{8}$ in. \times 18 teeth, free-wheel body made from ENIA steel forged, and wearing surfaces hardened to 600 HV; fitted with 108 steel balls, $\frac{1}{8}$ in. dia., chromium alloy, made to IS 2898
- Pedal assembly** Made to IS 628; pedal tubes of ERW 18 G. steel tube $\frac{5}{8}$ in. OD, made to IS 2484 and IS 2039, nickel and chromium plated; pedal axle of ENIA steel and wearing surfaces case hardened to 600 HV; stretcher bars of 4 G. HB wire, fitted with nuts on both ends; winged dust cap pressed from 18 G. MS sheet, nickel and chromium plated; ball race made from 14 G. CRCA sheet; and pedal cone made from ENIA steel and hardened to 600 HV, fitted with 48 balls $\frac{5}{32}$ in. dia. of chromium alloy steel, made to IS 2898; full rubbers, 4 in., of pyramid or diamond design, black
- Saddle** Men's full roadster size $10\frac{1}{2}$ in. \times $8\frac{1}{2}$ in. leather top, three-coil springs on double wire base, chromium plated.

COMPARISON OF MANUFACTURING IN SMALL- AND LARGE-SCALE SECTORS

The bicycle is an item of mass consumption and is used even in the remote areas of the country. It is produced in great quantities in both the large- and small-scale sectors. In both sectors economic production is feasible. In the large-scale sector the cost of production is kept low by mass production; in the small-scale sector it is kept low by reduced overheads. In the large-scale sector sophisticated automatic plants are used for mass production, but in the small-scale sector, semi-automatic or single-operation machines are used of a size to give suitable output. In the large-scale sector most of the parts and components required for a bicycle are manufactured in the unit itself. In the small-scale sector, on the other hand, not all of the parts and components are manufactured within the unit.

In the large-scale units, the manufacturing is divided into sections, depending upon the process. Pressed parts are manufactured in the press shop by presses capable of mass production. Turned parts are made on automatic machines. Components such as chains, hubs, free-wheels, spokes and nipples, mudguards and rims are made in specialized plants. The finishing shops for electroplating, stove enamelling and heat treatment generally have automatic plants and material-handling equipment. Assembly shops operate on a line production basis. Inspection is carried out at every stage of manufacture in accordance with standard specifications.

In the small-scale units, as stated earlier, the assemblers of complete bicycles make only a few parts such as frames, forks, seat stays, chain stays, handle-bars and certain other pressed parts. Electroplating and stove enamelling are done on comparatively simple equipment. The work pieces are handled manually or by simple trolleys. The specialized components are bought from large-scale industries, or specialized small-scale producers, or are imported.

The manufacturing process in the small- and large-scale sectors varies according to the scale of production, the type of machinery and the equipment used. The availability of raw materials influences the process of manufacture. However, for the manufacture of certain specialized components that must, for economy of scale, be produced in large numbers, the technologies employed by both sectors are similar. This is evident from the fact that many large- and small-scale units have identical plants for the manufacture of components such as chains, spokes and nipples. For components such as mudguards, rims and hubs, the large-scale units have sophisticated automatic plants that operate with specific types of raw materials only; the small-scale units have made innovations on the same principles by developing simpler plants. In these plants they can use

easily available raw materials. The following example illustrates the technical innovation of small-scale units for the manufacture of rims.

Rim manufacture in the large-scale sector

A cold-rolled steel strip of measured width is fed from a coil into an automatic machine consisting of two sets of forming rollers with a seam-welding unit between them. The first set of rollers forms the rim beads by curling the edges of the strip and forming the seam. As the strip passes on, both seams are automatically welded in the seam-welding section of the plant. The second set of rollers then forms the rim section and rolls it into a continuous helical coil. When a sufficient length of this coil is formed, it is taken to the next machine where the helical coil of rim section is cut into individual rims. The ends of the rim are then butt-welded in a butt-welding machine forming a complete circle of rim. The welded joint is cleaned on the inside and outside by profile grinding wheels. The rim is then re-rolled in a rim re-rolling machine to make it circular. Spoke holes are then punched in the rim by an automatic punching machine. Rims are polished on automatic rim polishing lathes and electroplated in automatic plating vats.

Rim manufacture in the small-scale sector

In this process, instead of bending a continuous length of cold-rolled steel, strips are cut from sheets into exact lengths to form single rims. Each strip is fed into a simple rolling machine that forms the beads (including seam) and at the same time rolls the rim section and bends it into circular shape. The ends of the rolled rim are then trimmed to the correct circumference in a trimming machine and are butt-welded in a butt-welding machine. After cleaning the inner and outer surface of the rim at the weld joint, the rim is seam-welded in a seam-welding machine. Next it is made into a true circle in a rim-rolling machine after which the spoke and inflator holes are punched. The rims are electroplated on simple equipment. The difference in this method is that steel strips are cut from sheets instead of from cold-rolled strips in coils. If cold-rolled strips in coils are not available, the automatic rim-making machine used by large-scale industries cannot be used.

In both sectors, therefore, economic production has been established and the manufacturing processes enable quality standards in production to be achieved.

COST OF PRODUCTION AGAINST CAPITAL INVESTMENT IN THE SMALL- AND LARGE-SCALE SECTORS

The costs of production of various parts and components of a bicycle differ in accordance with the capital investment in the small- and large-scale sectors. In India, certain items are produced at a lower cost in the small-scale sector, others at a higher cost. The small-scale bicycle component industry has been able to keep down the cost of production by using several technical innovations

and by having, for example, a proprietor supervising the operation of his factory. The overhead is less in the small-scale sector. The technical innovations have helped to establish economic production of the quantity suitable for the small scale.

It is difficult to make a precise comparison of the costs of production for components and parts in the small- and large-scale sectors. However, approximate costs of production in India in both sectors for certain items have been estimated and are listed below in table 2.

Table 2

PRODUCTION COSTS FOR BICYCLE COMPONENTS
AND PARTS IN INDIA, 1966

		<i>Small-scale sector (Rupees)</i>	<i>Large-scale sector (Rupees)</i>
Chains	per pair	4.00	4.50
Spokes, nipples and washers	per bicycle (1/2 gross)	3.25	3.50
Mudguards	per pair	3.00	3.00
Rims	each	14.00	14.00
Hubs	per pair	5.00	5.50
Chain-wheel and cranks	per set	5.00	4.50
Free-wheels	each	3.75	3.50
Pedals	per pair	3.00	4.00
BB shells	each	1.75	1.50
Turned components	per set	2.50	2.00
Fork, frame, handle-bar, pressed parts		50.00	60.00

The range of costs of production given above in table 2 for small- and large-scale sectors depends upon the capital investment, the manufacturing method, the quality of the item and the scale of production. It is therefore imperative for developing countries to plan their bicycle industry in accordance with the estimated demand for domestic use and for export. The Indian experience indicates that for small countries, the bicycle industry can be economically planned within the small-scale sector. According to the present definition, a small-scale unit in India is one with investment in machinery and equipment up to Rs. 750,000 (US\$100,000) irrespective of the investment in land, buildings, working capital or number of workers employed. Production in either sector can be economic.

Economic production within the small-scale sector is feasible on different scales of production. Details of manufacturing costs at two levels of production (one for 25,000 bicycles per year and the other for 15,000) are given in chapter 12.

SPECIFICATIONS OF BICYCLE PARTS AND COMPONENTS

The bicycle is divided into the following sub-assemblies, with each sub-assembly further divided into groups and then into parts that are designated by code numbers. Bicycle sub-assemblies and their code numbers are:

1. Frame set, 1000
2. Handle-bar, 2000
3. Rear wheel, 3000
4. Front wheel, 4000
5. Brake set, 5000
6. Transmission, 6000

Figure 2 shows the sub-assemblies and groups with their code numbers. The first digit of the code number indicates the sub-assembly, the second defines the group and the last two digits give the parts number. This system of code numbers can be used to classify parts on job cards, to issue material from stores, to identify finished parts and to number them in catalogues. A fifth digit can be added to this system to identify models.

The details of parts, materials required, number of parts per bicycle, and prescribed standards for all sub-assemblies are given in tables 3 to 16 below. The parts in the list are arranged in the order required for the manufacture of the sub-assembly.

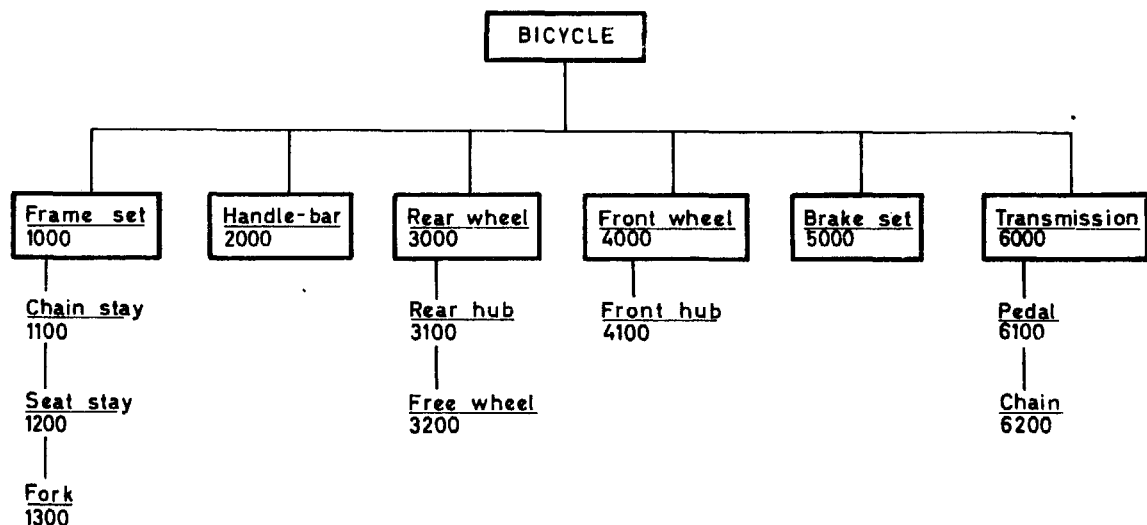


Figure 2. Sub-assemblies and groups of the bicycle and their code numbers

FRAME SET*Table 3*

SUB-ASSEMBLY, FRAME SET 1000 (FIGURE 3)

<i>Code No.</i>	<i>Name</i>	<i>Quantity per bicycle</i>	<i>Material</i>	<i>Remarks</i>
1001	Bottom bracket	1	Malleable cast iron	
1002	Seat tube	1	1½ in. × 20 G. ERW steel tube	IS 2484 and IS 2039
1003	Seat tube liner	1	20 G. MS sheet	
1004	Seat lug	1	16 G. MS sheet annealed	
1005	Down tube	1	1½ in. dia. × 18 G. ERW steel tube	IS 2484 and IS 2039
1006	Down tube liner	1	16 G. MS sheet	
1007	Bottom head lug	1	16 G. MS sheet	
1008	Top tube	1	1 in. dia. × 20 G. ERW steel tube	IS 2484 IS 2039
1009	Top tube liners	2	16 G. MS sheet	
1010	Top head lug	1	20 G. MS sheet annealed	
1011	Head tube	1	1¼ in. dia. × 20 G. ERW steel tube	IS 2484 and IS 2039
1012	Riveting pins	10	1/8 in. dia. HB steel wire	
1100	Chain stay	1		Details of parts are given in table 4
1013	Chain stay bolt	1	3/8 in. dia. BSW	Purchased
1014	Chain stay nut	1	3/8 in. dia. BSW	Purchased
1015	Chain stay washer	1	3/8 in. dia. MS	Purchased
1200	Seat stay	1		Details of parts are given in table 5
1016	Seat lug bolt	1	3/8 in. dia. BSW	Purchased
1017	Seat lug nut	1	3/8 in. dia. BSW	Purchased
1018	Pump pegs on frame	2	3/16 in. dia. MS	Purchased
1019	Seat pillar	1	1 in. dia. × 18 G. ERW tube	Nickel and chromium plated
1020	Bottom ball race seating	1	16 G. CRCA sheet	Nickel and chromium plated
1021	Top ball race seating	1	16 G. CRCA sheet	Nickel and chromium plated
1300	Fork	1		Details of parts are given in table 6
1022	Crown race	1	40 mm dia. ENIA steel	Hardened to 600 HV; IS 226:1962

Table 3 (continued)

Code No.	Name	Quantity per bicycle	Material	Remarks
1023	Chrome steel balls	60	1/8 in. dia. MS	Purchased
1024	Bottom inner ball race	1	40 mm dia. ENIA steel	Hardened to 600 HV; IS 266:1962
1025	Top inner ball race	1	40 mm dia. ENIA steel	Hardened to 600 HV; IS 226:1962
1026	Screwed race	1	45 mm dia. ENIA steel	Bicycle thread 1.06 mm pitch; nickel and chromium plated
1027	Spacing washer	1	40 mm dia. MS	Nickel and chromium plated
1028	Lamp bracket	1	10 G. MS sheet	Nickel and chromium plated
1029	Locking nut	1	40 mm across flats, MS hexagonal bar	Bicycle thread 1.06 mm pitch; nickel and chromium plated
1030	Rear mudguard	1	24/22 G. CRCA sheet or strip	
1031	Rear mudguard inner bridge	1	16 G. MS sheet	Spot welded with 1030 at the rear side
1032	Rear mudguard stays	2	3/16 in. dia. MS	Assembled with 1030 and 1031
1033	Rear mudguard tabs	2	16 G. MS sheet	Spot and gas welded with 1032
1034	Stay nuts	2	3/16 in. BSW	Purchased; for fixing with 1031
1035	Rear mudguard clip	1	20 G. MS sheet	For fixing on the bridge of chain stay
1400	Mudguard reflector	1	20 G. MS sheet	Purchased
1036	Front mudguard	1	24/22 G. CRCA sheet or strip	
1037	Front mudguard inner bridge	1	16 G. MS sheet	Spot welded with 1036 at the rear side
1038	Front mudguard stays	2	3/16 in. dia. MS	Assembled with 1036 and 1037
1039	Front mudguard tabs	2	16 G. MS sheet	Spot and gas welded with 1038
1040	Stay nuts	2	3/16 in. BSW	Purchased
1041	Mud flap	1	Rubber	Purchased
1042	Round-head screws, nuts and washers	3 each	1/8 in. BSW	Purchased
1043	Front mudguard set screw	1	3/16 in. BSW	Purchased; for fixing with fork
1044	BB axle	1	25 mm dia. ENIA steel	Hardened to 600 HV

Table 3 (continued)

Code No.	Name	Quantity per bicycle	Material	Remarks
1045	Loose liner	1	16 G. MS sheet	
1046	Steel balls	22	Chromium alloy 1/4 in. dia.	Purchased
1047	BB fixed ball cup	1	45 mm dia. ENIA steel	Hardened to 600 to 800 HV
1048	BB adjustable ball cup	1	40 mm dia. ENIA steel	Hardened to 600 to 800 HV
1049	Locking nut	1	50 mm dia. MS	IS 226:1962; 24 TPI (RH) nickel and chromium plated

Table 4

SUB-ASSEMBLY, FRAME SET 1000. GROUP, CHAIN STAY 1100 (FIGURE 3)

Code No.	Name	Quantity per bicycle	Material	Remarks
1101	Chain stay tubes	2	7/8 in. dia. × 18/20 G. ERW tube	One left hand, one right hand
1102	Liners (rear)	2	18 G. MS sheet	
1103	Liners (front)	2	18 G. MS sheet	
1104	Chain stay bridge	1	18 G. MS sheet	

Table 5

SUB-ASSEMBLY, FRAME SET 1000. GROUP, SEAT STAY 1200 (FIGURE 3)

Code No.	Name	Quantity per bicycle	Material	Remarks
1201	Seat stay tubes	2	5/8 in. × 20 G. ERW steel tube	One left hand, one right hand
1202	Liners (top)	2	20 G. MS sheet	
1203	Liners (bottom)	2	20 G. MS sheet	
1204	Seat stay bridge	1	20 G. MS sheet	Gas welded for connecting LH and RH seat stay tubes 1201

Tests for frame made to IS 623 : 1963

Trueness. The frame must be fixed (see figure 3a) on a suitable surface plate with bottom bracket perpendicular to it. The heights of the centre lines of the tubes and the chain and seat stays are then measured from the surface plate. These heights should not vary by more than ± 1.0 mm.

Table 6

SUB-ASSEMBLY, FRAME SET 1000. GROUP, FORK 1300 (FIGURE 3)

Code No.	Name	Quantity per bicycle	Material	Remarks
1301	Fork blade (right)	1	ERW tapered tube or 16 G. MS sheet	
1302	Fork blade (left)	1	ERW tapered tube or 16 G. MS sheet	
1303	Fork blade liners (bottom)	2	16 G. MS sheet	Liner is inserted into the open end of the fork blades right and left, before pressing the end
1304	Fork blade liners (top)	2	16 G. MS sheet	
1305	Fork crown	1	16 G. CRCA sheet or strip	
1306	Box pieces	4	16 G. MS sheet	
1307	Ring	1	1 $\frac{1}{8}$ in. dia. 16 G. MS	Assembled over the fork column tube in- side fork crown, tack welded
1308	Fork column	1	1 in. dia. \times 16 G. ERW tube or butted column tube; top 1 in. dia. \times 16 G. and bottom 1 in. dia. \times 10 G.	Threaded 1.06 mm pitch, bicycle thread
1309	Fork column liner	1	16 G. MS sheet	
1310	Fork crown cover	1	22 G. MS or brass sheet	Nickel and chromium plated

Load test. For this test (see figure 3b) the chain stay at the frame should be clamped on a suitable lug mounted on a bench in such a manner that the top tube of the frame is horizontal. The head tube should rest on a roller support. The frame is loaded at the points where the handle-bar and the seat are to be fitted, with 23 kg and 82 kg weights respectively. The loads are then increased to 100 kg and 350 kg respectively, the maximum loads kept for two minutes and released. The frame should not show any deformation at the point E.

Test for finish. A solid steel ball measuring 13 mm in dia. is dropped from a height of 1.5 metres on any painted portion of the frame. The area of paint struck by the steel ball should stand the impact without showing any sign of tear or peeling.

The frame is kept dipped for one hour in a 5 per cent common salt solution at the following temperatures: black enamel paint 80°C; other enamel paints 60°C. The paint must not soften, peel off or show change in colour.

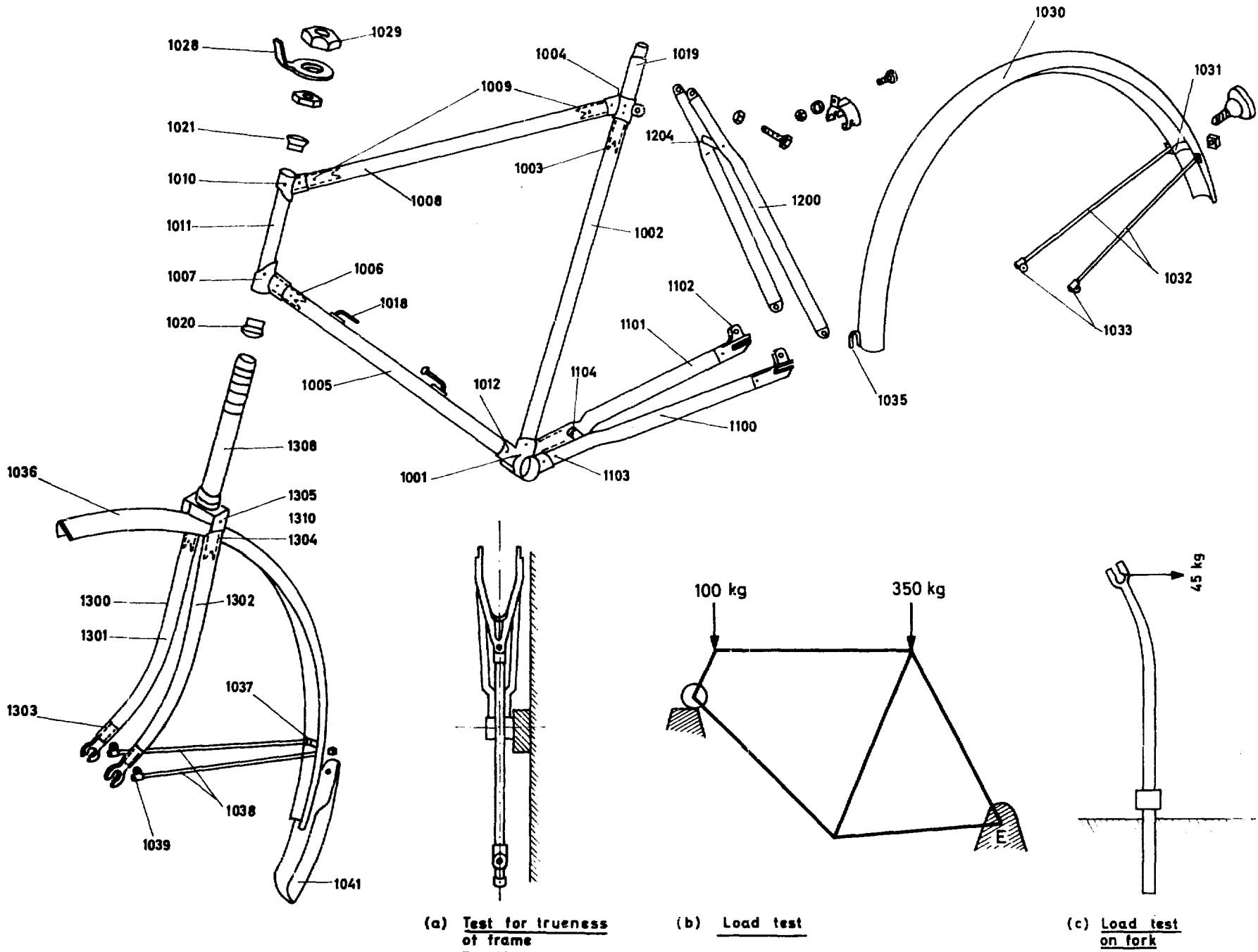


Figure 3. Frame assembly

Tests for fork made to IS 2061 : 1962

Load test. The stem of the fork must be clamped rigidly (see figure 3c) with its axis horizontal and the fork ends turned upward keeping the fork crown clear of the clamp jaws by 8 mm. A vertical load is applied on the fork ends, where the front wheel axle is to be fitted, so that the load acts on both ends equally. The load is then increased until it reaches 45 kg and held for 30 seconds. The fork must not show a permanent set of more than 1.6 mm at the point of loading.

Expansion test. The distance between the free ends of fork legs, when expanded 13 mm by pushing a mandrel or any suitable device between them, should not show any measurable permanent increase under ordinary methods of measurement.

Test for finish is the same as for the frame.

HANDLE-BAR

Table 7

SUB-ASSEMBLY, HANDLE-BAR 2000 (FIGURE 4)

Code No.	Name	Quantity per bicycle	Material	Remarks
2001	Handle-bar tube	1	7/8 in. dia. × 16 G. ERW steel tube	
2002	Handle-bar lug	1	14 G. CRCA sheet	
2003	Handle-bar stem tube	1	7/8 in. dia. × 16 G. ERW steel tube	
2004	Eye bolts	4	15 mm dia. MS	
2005	Eye bolt washers	4	18 mm dia. MS	
2006	Eye bolt nuts	4	MS bar 1/4 in. dia.	Inserted into handle- bar tube for fixing eye-bolt
2007	Left roller lever	1	10 mm dia. MS	
2008	Right roller lever	1	10 mm dia. MS	
2009	Roller lever spring	1	16 G. spring steel wire	Purchased
2010	Brake tab front	1	10 G. MS sheet	
2011	Brake tab rear	1	10 G. MS sheet	
2012	Roller lever washers	2	10 G. MS sheet	
2013	Roller lever nuts	2	3/8 in. BSW	
2014	Brake rod front	1	10 G. HB wire	
2015	Brake rod rear	1	10 G. HB wire	
2016	Expander bolt	1	7.94 mm × 0.98 pitch bicycle thread	For fixing handle-bar to fork

Table 7 (continued)

Code No.	Name	Quantity per bicycle	Material	Remarks
2017	Expander bolt washer	1	10 G. MS sheet	
2018	Cone	1	7/8 in. dia. MS	
2019	Handle-bar grips	2	Celluloid	Purchased

Test for handle-bar IS 625 : 1963

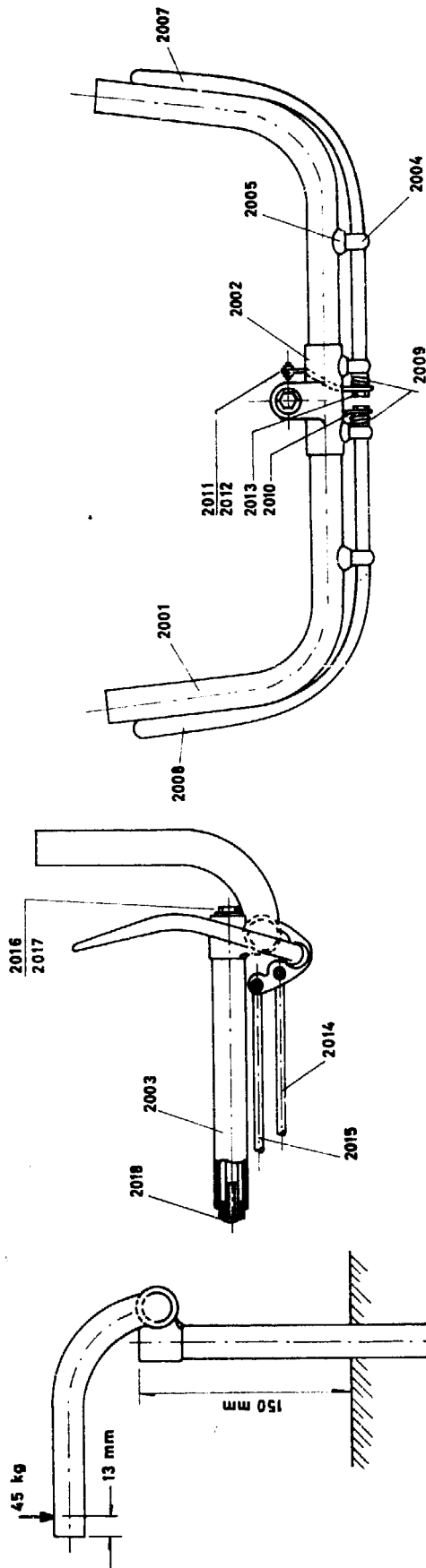
The handle-bar should be fixed on the handle stem (after removing the expander bolt and cone and the stem plugged in at the point of grip) in such a manner that the stem is vertical and the clear length between the top of the straight portion of the handle-bar and the fixing arrangement is 150 mm, as shown in figure 4a. A load of 45 kg is then applied gradually and simultaneously on each end of the handle 13 mm from the end, as shown in the figure, and held for two minutes. The permanent set at the ends of the handle-bar must not exceed 2 millimetres.

REAR WHEEL

Table 8

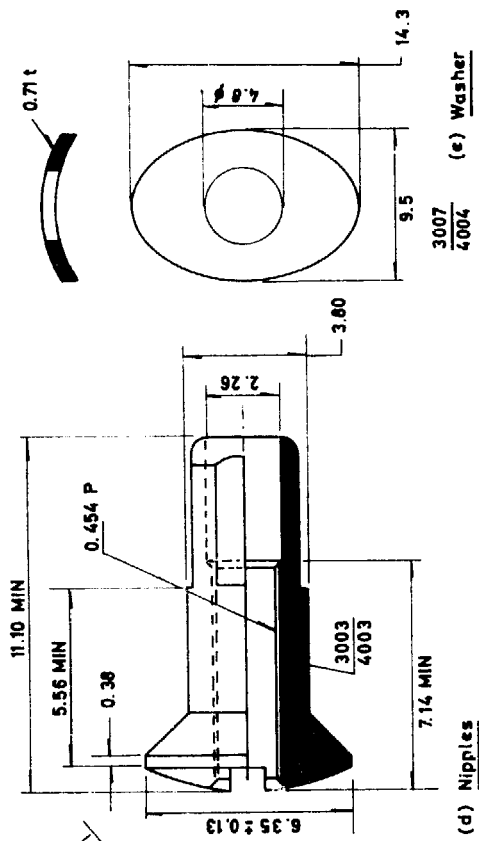
SUB-ASSEMBLY, REAR WHEEL 3000 (FIGURE 4)

Code No.	Name	Quantity per bicycle	Material	Remarks
3001	Rim (rear)	1	20/24 G. CRCA strip or sheet	Tolerance on circumference as measured on bead seat +0.50, -0.75 mm
3002	Spokes	40	15 G. high carbon steel wire	Tolerance on length of finished spoke +0.0, -0.8 mm
3003	Nipples	40	Free cutting extruded brass 3.8 mm dia.	
3005	Tape	1	Rayon staple fibre 13.5 mm wide × 1 mm thick, 2/2 twill	Purchased. Protects the cycle tube from damage
3006	Buckle for tape	1	23 G. tin plate	
3100	Rear hub	1		Details of parts are given in table 9
3007	Washers	40	23 G. tin plate	
3200	Free-wheel	1		Details of parts are given in table 10
3008	Tire	1	28 in. × 1 1/2 in.	Purchased
3009	Tube with valve	1	To suit above	Purchased



(a) Load test on handle-bar

(b) Handle-bar (2000)



(c) Spokes

(d) Nipples

(e) Washer

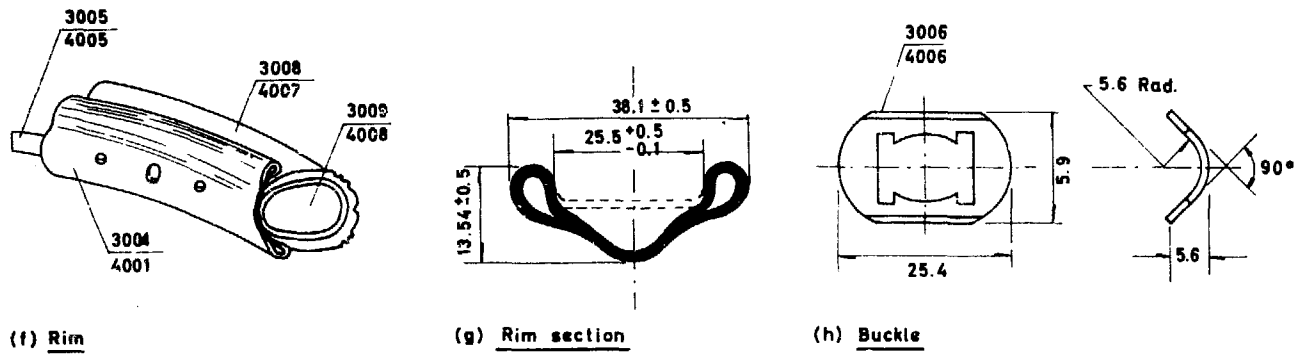


Figure 4. Handle-bar, rear and front wheel (rear wheel 3000, front wheel 4000)

Table 9

SUB-ASSEMBLY, REAR WHEEL 3000. GROUP, REAR HUB 3100 (FIGURE 5)

Code No.	Name	Quantity per bicycle	Material	Remarks
3101	Rear hub shell	1	11/16 in. dia. × 16 G. seamless steel tube	Nickel and chromium plated
3102	Distance piece	1	14 G. MS sheet	
3103	Rear hub ball race cups	2	14 G. CRCA sheet	Wearing surface case hardened to 0.2 mm depth, 600 HV and polished
3104	Spoke flanges	2	12 G. CRCA sheet	RH flange threaded to fit free-wheel
3105	Rear hub axle	1	3/8 in. dia. bright steel bar	
3106	Steel balls	18	1/4 in. dia. chromium alloy	Purchased
3107	Fixed cone	1	11/16 in. dia. ENIA steel	Case hardened to 0.2 mm depth, 600 HV chemically rust-proofed or blued
3108	Adjustable cone	1	11/16 in. dia. ENIA steel	Case hardened to 0.2 mm depth, 600 HV chemically rust-proofed or blued
3109	Dust cap washer	2	14 G. CRCA sheet	Nickel and chromium plated
3110	Nuts	2	3/8 in. BSW	Purchased
3111	Washers	2	3/8 in. dia. MS	Purchased
3112	Oil clip	1	25 G. spring steel sheet	Tempered and blued
3113	Chain adjusters	2	1/4 in. dia. MS	
3114	Chain adjuster clips	2	20 G. MS sheet	Nickel and chromium plated
3115	Chain adjuster nuts	2	3/16 in. dia. BSW	Purchased

Table 10

SUB-ASSEMBLY, REAR WHEEL 3000. GROUP, FREE-WHEEL 3200 (FIGURE 5)

Code No.	Name	Quantity per bicycle	Material	Remarks
3201	Free wheel body	1	2 $\frac{1}{2}$ in. dia. ENIA steel	Forged; wearing surface hardened to 600 HV
3202	Sprocket wheel	1	3 $\frac{1}{4}$ in. dia. ENIA steel	
3203	Free-wheel pawls	2	Cold drawn steel 0.167 in. wide	Hardened to 800 HV
3204	Pawl pins	2	1/16 in. MS wire	
3205	Pawl springs	2	Spring steel 0.167 in. wide 36 G.	Tempered
3205 (a)	Pawl washers	2	28 G. steel strip	Purchased
3206	Steel balls	108	1/8 in. dia. chromium alloy	
3207	Free-wheel cone	2	3 $\frac{1}{4}$ in. dia. ENIA steel	Wearing surfaces hardened to 600 HV; ball races to be finished smooth

Test for rim made to IS 624 : 1961

Compression test. The test is conducted on a suitable device that is capable of loading the rim in the manner described below. The rim is held between two supports, keeping the weld at right angles to the line joining the points of loading. The load is applied to give a vertical compression of 30 kg to the rim, then slowly increased in steps of approximately 10 kg up to 70 kg, and held for two minutes before it is released. The rim is taken up and examined for permanent set on the diameter with a suitable measuring device. The permanent set should not exceed 2.5 millimetres.

Test for hubs

Deflexion test. The front and rear hub assemblies are revolved on their spindles. The concentricity of hub shell and ball race, when gauged at the periphery of the flange, must not be more than 0.3 mm. The rear hub assembly is revolved on its spindle. When gauged at the periphery of the threaded portion the concentricity should be not more than 0.3 millimetres.

Test for free-wheel

The chain sprocket should stand being compressed diametrically by 5 per cent of its internal diameter, without showing cracks or breaks.

The free-wheel when suitably mounted and the chain sprocket rotated, should not have an axial or radial deflexion of more than 0.2 mm (or 0.008 in.). The deflexion is measured at the circular edge of the free-wheel.

FRONT WHEEL

Table 11

SUB-ASSEMBLY, FRONT WHEEL 4000 (FIGURE 4)

Code No.	Name	Quantity per bicycle	Material	Remarks
4001	Rim (front)	1	20/24 G. CRCA strip or sheet	Tolerance same as for 3001
4002	Spokes	32	Same as part No. 3002	
4003	Nipples	32	Same as part No. 3003	
4004	Washers	32	Same as part No. 3007	
4100	Front hub			Details of parts are given in table 12
4005	Tape	1	Same as part No. 3005	
4006	Buckle for tape	1	Same as part No. 3006	
4007	Tire	1	Same as part No. 3008	
4008	Tube with valve	1	Same as part No. 3009	

Table 12

SUB-ASSEMBLY, FRONT WHEEL 4000. GROUP, FRONT HUB 4100 (FIGURE 5)

Code No.	Name	Quantity per bicycle	Material	Remarks
4101	Front hub shell	1	1 ¹ / ₆ in. dia. × 16 G. seamless steel tube	Nickel and chromium plated
4102	Front hub ball race cups	2	14 G. CRCA sheet	Case hardened to 0.2 mm depth, 600 HV and polished
4103	Spoke flange	2	12 G. CRCA sheet	Nickel and chromium plated; pressed on ends of front hub shell
4104	Front hub axle	1	5/16 in. dia. bright steel bar	
4105	Fixed cone	1	1 ¹ / ₁₆ in. dia. ENIA steel	Case hardened to 0.2 mm depth, 600 HV chemically rust-proofed or blued
4106	Adjustable cone	1	1 ¹ / ₁₆ in. dia. ENIA steel	Case hardened to 0.2 mm depth, 600 HV chemically rust-proofed or blued
4107	Steel balls	18	1/4 in. dia. chromium alloy steel	Purchased

Table 12 (continued)

Code No.	Name	Quantity per bicycle	Material	Remarks
4108	Dust cap washer	2	14 G. CRCA sheet	Nickel and chromium plated
4109	Washers	2	5/16 in. dia. MS	Purchased
4110	Nuts	2	5/16 in. BSW	Purchased
4111	Oil clip	1	25 G. spring steel sheet	Tempered and blued

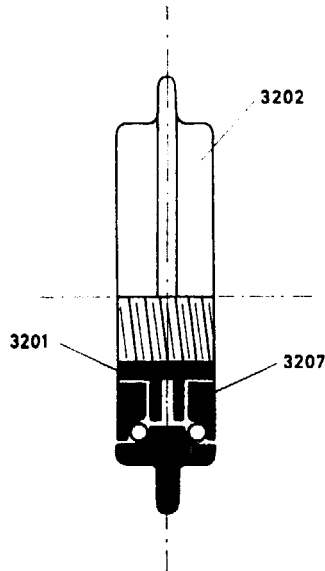
The tests for the front rim and hub are the same as for rear rim and rear hub.

BRAKE SET

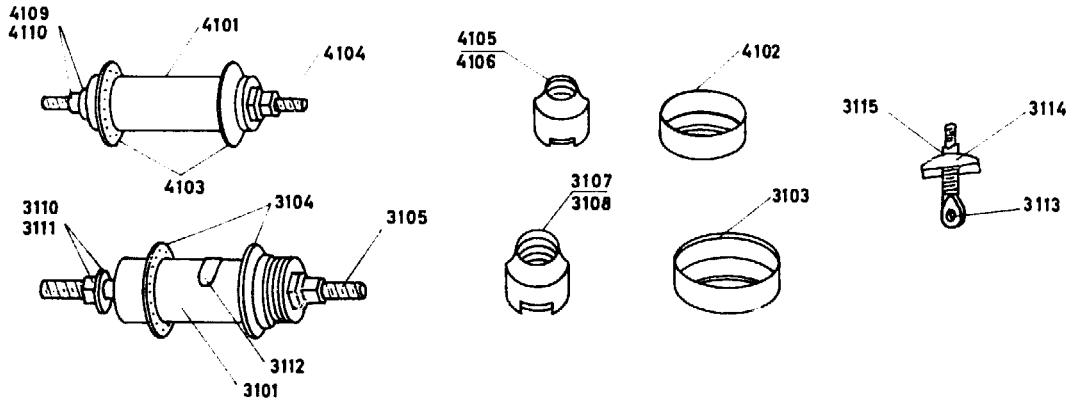
Table 13

SUB-ASSEMBLY, BRAKE SET 5000 (FIGURE 5)

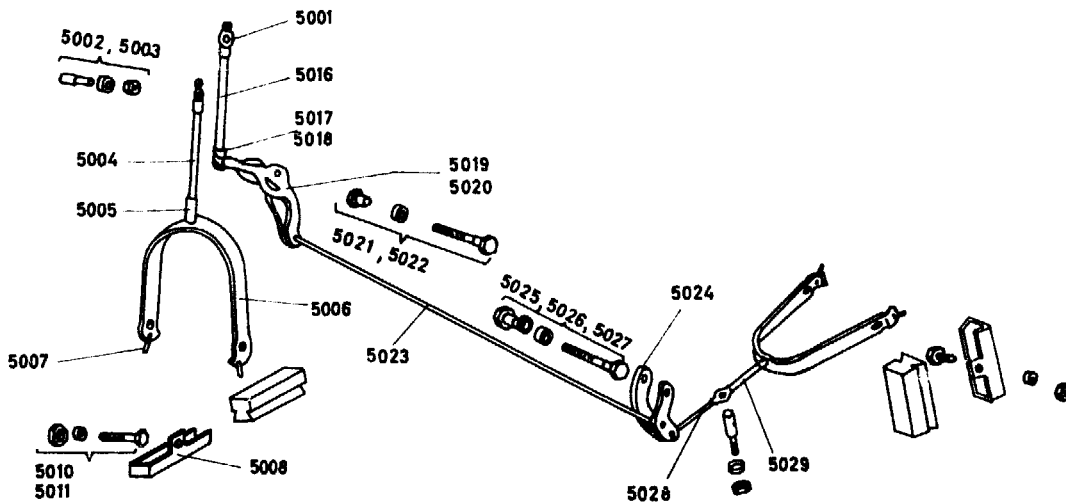
Code No.	Name	Quantity per bicycle	Material	Remarks
5001	Connector for brake tubes	3	5/8 in. dia. MS	
5002	Draw bolts and nuts	3 each	1/4 in. dia. BSW	Purchased
5003	Washers	3	1/4 in. dia. MS	
5004	Front brake tube	1	3/32 in. ID MS	
5005	Brake stirrup connexion	2	7/32 in. OD and 5/32 in. ID MS tube	
5006	Brake stirrup	1 front 1 rear	13 G. MS sheet	
5007	Stirrup pin	4	4 G. HB wire	
5008	Brake shoes	4	18 G. MS cold-rolled sheet	
5009	Brake block	4	Moulded rubber	Purchased
5010	Bolts and nuts	4 each	3/16 in. dia. BSW	Purchased
5011	Washer	4	3/16 in. dia. MS	Purchased
5012	Brake clips (outer)	4	18 G. MS cold-rolled sheet	Nickel and chromium plated
5013	Brake clips (inner)	4	14 G. cold-rolled sheet	Nickel and chromium plated
5014	Slotted cheese head screws and nuts	4 each	3/16 in. dia. BSW	Purchased
5015	Washers	8	3/16 in. dia. MS	Purchased
5016	Rear brake tube	1	3/32 in. ID MS	
5017	Tube connector bottom	1	3/4 in. dia. MS	



(a) Free-wheel 3200



(b) Front hub 4100, rear hub 3100 and parts



(c) Brake set 5000

Figure 5. Free-wheel, hubs, brake set

Table 13 (continued)

Code No.	Name	Quantity per bicycle	Material	Remarks
5018	Grub screw	1	1/8 in. dia. BSW	
5019	Brake lever (bottom)	1 LH 1 RH	14 G. MS sheet	
5020	Rivets	3	1/8 in. dia. MS	
5021	Bolt	1	1/2 in. dia. MS	
5022	Nut	1	1/4 in. dia. BSW	Purchased
5023	Washer	1	1/4 in. dia. MS	Purchased
5024	Bottom long brake rod	1	9 G. HB wire	
5025	Bell crank	1 LH 1 RH	14 G. MS sheet	
5026	Bell crank bolt	1	1/2 in. dia. MS	
5027	Bell crank nut	1	1/4 in. dia. BSW	Purchased
5028	Bell crank washer	1	1/4 in. dia. MS	Purchased
5029	Bottom small brake rod	1	9 G. HB wire	
5030	Stirrup brake tube	1	3/32 in. ID MS	

TRANSMISSION

Table 14

SUB-ASSEMBLY, TRANSMISSION 6000 (FIGURE 6)

Code No.	Name	Quantity per bicycle	Material	Remarks
6001	Chain wheel	1	3 mm thick MS sheet	Thickness of teeth to be 2.80 to 3.05 mm
6002	RH crank	1	32 mm dia. MS bar	Tapped to 20 TPI Whitworth RH thread
6003	Cotter pins	2	10 mm dia. MS bar	1/4 in. × 26 TPI bicycle thread
6004	Washers	2	10 mm dia. MS	Purchased
6005	Nuts	2	1/4 in. × 26 TPI bicycle thread	Purchased
6006	Spring washers	2	7 mm ID × 16 G. MS	Purchased
6007	LH crank	1	32 mm dia. MS bar	Tapped to 20 TPI Whitworth LH thread
6100	Pedals	2		Details of parts are given in table 15
6200	Bicycle chain	1		Details of parts are given in table 16

Table 15

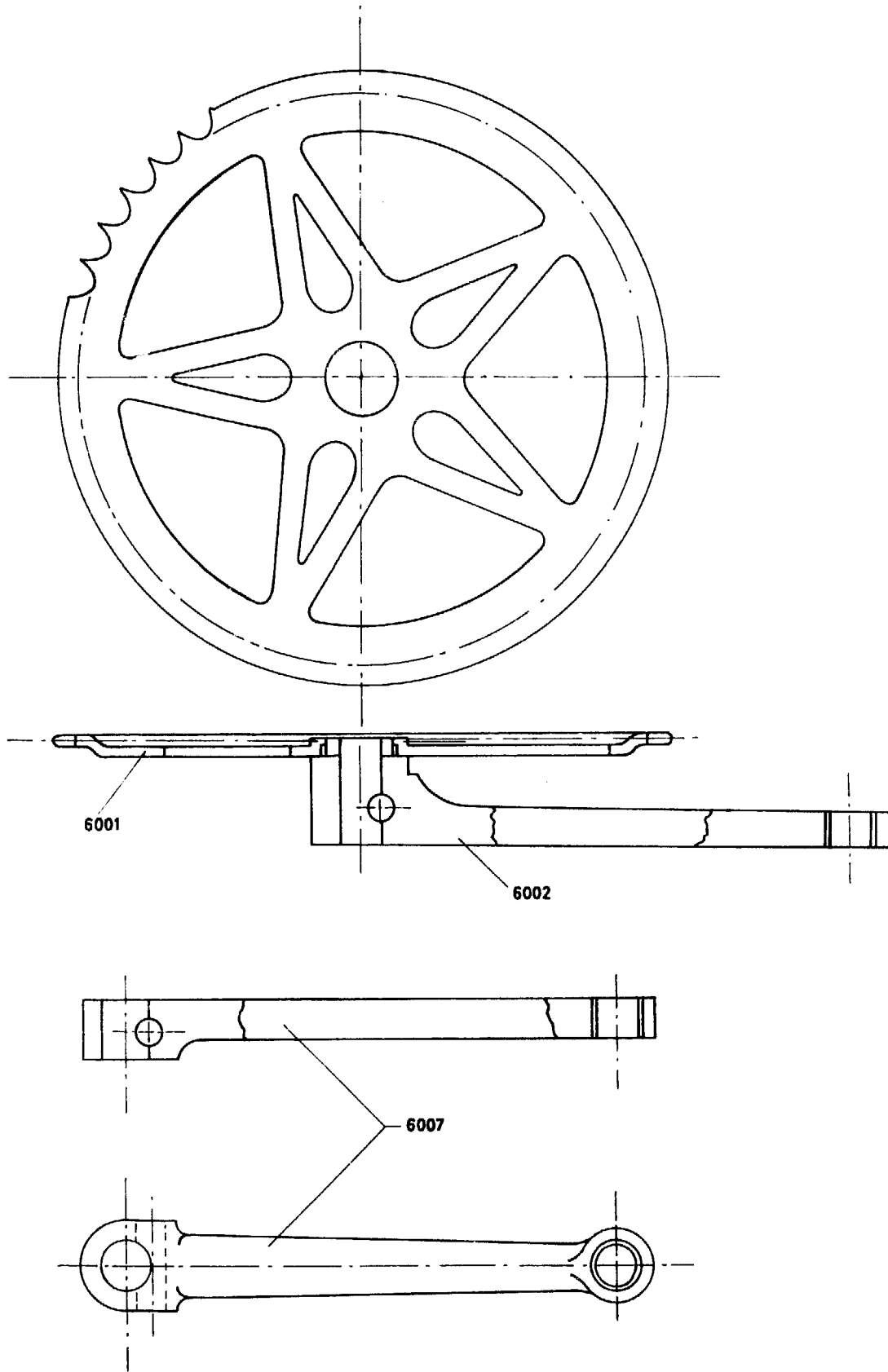
SUB-ASSEMBLY, TRANSMISSION 6000. GROUP, PEDAL 6100 (FIGURE 6)

Code No.	Name	Quantity per bicycle	Material	Remarks
6101	Pedal tubes	2	$5/8$ in. OD 18 G. ERW steel tube	Nickel and chromium plated
6102	Ball racer	4	$5/8$ in. OD 14 G. CRCA sheet	Case hardened to 0.2 mm depth, 600 HV on wearing surface and polished
6103	Pedal rubbers	4	Moulded rubber	Purchased
6104	Stretcher bars	4	4 G. HB wire	
6105	Pedal plates	4	14 G. MS sheet	
6106	Pedal axle balls	48	$5/32$ in. dia. chro- mium alloy	Purchased
6107	Pedal axle	1 LH 1 RH	$7/8$ in. dia. ENIA steel	Wearing surfaces case hardened to 0.2 mm depth, to 600 HV. bicycle thread 0.98 mm pitch for outer end and 1.27 mm pitch for crank end. RH thread used for crank end for RH axle. LH thread used for crank end for LH axle
6108	Pedal cones	2	$11/16$ in. dia. ENIA steel	Case hardened to 0.2 mm depth, 600 HV and polished
6109	Washers	2	$5/16$ in. dia. MS	Purchased
6110	Nuts	2	$5/16$ in. dia. BSW	Purchased
6111	Winged dust cap	2	18 G. MS sheet	
6112	Stretcher bar nuts	8	$3/16$ in. BSW	Purchased
6113	Spring lock washers	8	$3/16$ in. dia. MS	Purchased

Test for chain wheel made to IS 1281 : 1958

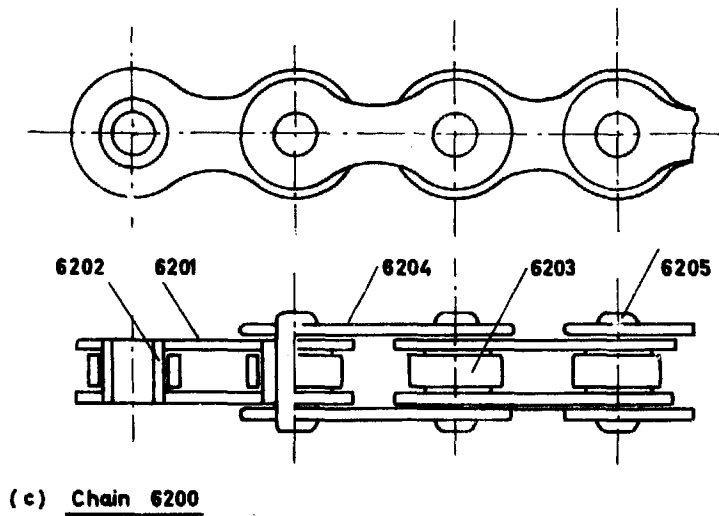
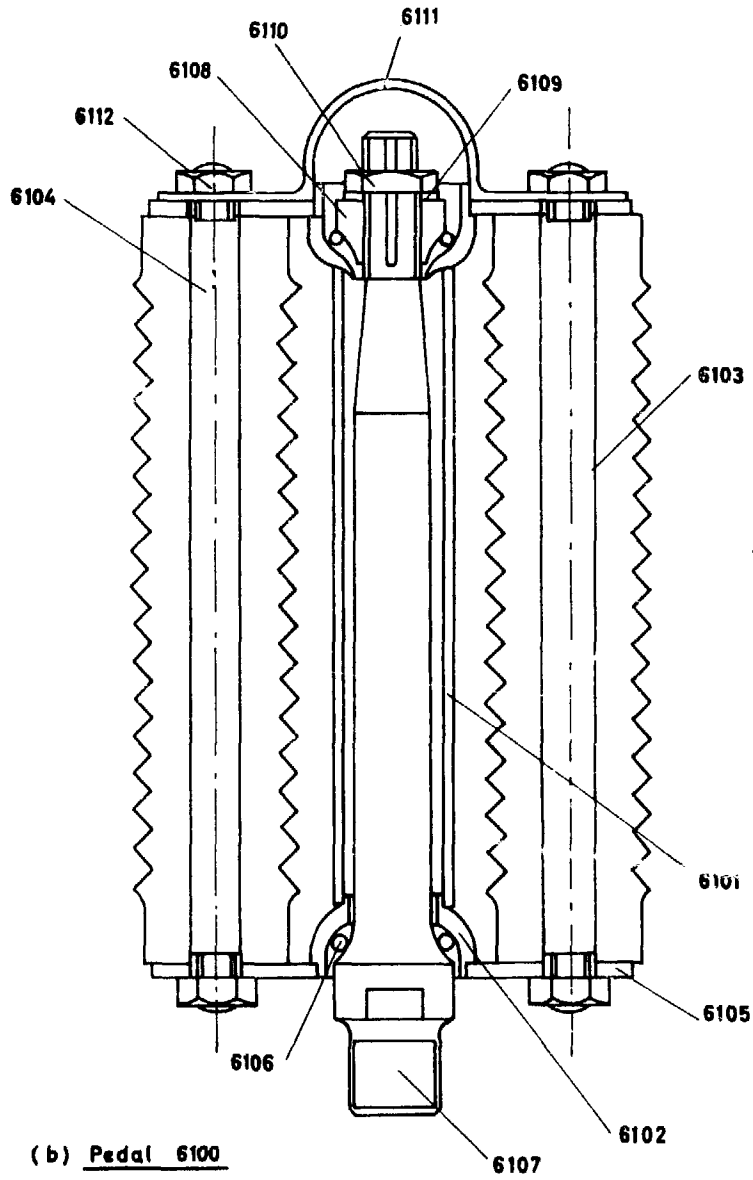
The crank chain wheel assembly is tested as follows.

The assembly is rigidly fixed in a vertical plane, the crank horizontal. Weight is then applied on the hole for the pedal spindle. The assembly should sustain a weight of 227 kg (or 500 lbs) without breaking at the joint, loosening or showing signs of yielding.



(a) Chain wheel and crank 6001, 6002

Figure 6. Transmission:



chain wheel and crank, pedal, chain

Table 16

SUB-ASSEMBLY, TRANSMISSION 6000. GROUP, CHAIN 6200 (FIGURE 6)

Code No.	Name	Quantity per bicycle	Material	Remarks
6201	Inner plates	112	Cold-rolled bright steel strip 1 mm thick, 48 to 51 mm wide in coils	
6202	Bushes	112	Cold-rolled bright steel strip 0.7 to 0.75 mm thick in coils 5 to 5.5 mm wide	Heat treated to hardness of 600 HV
6203	Rollers	112	Cold-rolled bright strip soft annealed 1 mm thick in coils 55 to 60 mm wide	Heat treated to hardness of 600 HV
6204	Outer plates	112	Same as for part 6201	
6205	Bearing pins	111	Precision bright drawn steel wire semi-hard 3.60 mm to 3.68 mm dia.	
6206	Spring clip	1	Spring steel 1 mm thick	
6207	Connecting pin	2	Case-hardening steel wire 3.6 mm dia.	

Test for pedal made to IS 628 : 1963

A minimum of one pedal assembly or 1 per cent of the lot is selected at random for testing.

The spindle is then subjected to a bend test. The spindle should withstand being bent until the included angle of the two arms of the deflected axis becomes 170° (or less) under load without breaking or cracking between the two supports.

Tests for chain made to IS 627 : 1961

Tensile breaking load test. This test is performed in accordance with the instructions given in the following paragraph. The number of such tests should be agreed upon by the supplier and the purchaser, but normally should not exceed one for every 250 chains.

A minimum length of 127 mm, either containing a joint or without a joint, is cut from the chain; its ends are attached to the shackles of the testing machine in such a manner that the pull is applied axially. The shackles are designed to

allow universal movement. The minimum breaking load should not be less than 820 kg.

Proof load test. The full length of the chain, when subjected to a load of 270 kg, should not show any permanent set.

Specifications for finish of parts

Several parts such as frame, fork, chain stay, seat stay, mudguards are to be stove enamelled. The handle-bar, brake set, rims, hubs, steering head parts, chain wheel and cranks, pedal parts, crown covers, spokes and nipples are to be electroplated. The general specifications for enamelling and electroplating are given below.

Enamelling

All enamelled parts should be thoroughly cleaned by sand-blasting, shot-blasting or pickling to free them of rust, scale and oily substances. They should then be chemically rust-proofed (bonderized), stove enamelled, and finally polished to a glossy finish.

Electroplating

All electroplated parts should be nickel coated to a minimum 0.015 mm thickness and then chromium plated to a minimum 0.0003 mm thickness. All parts should be polished bright or alternatively bright plated.

MANUFACTURE OF PARTS AND ASSEMBLY OF A COMPLETE BICYCLE

In the small-scale sector there are two types of economically viable unit: (a) units manufacturing parts such as frames, or pressed parts and assembling complete bicycles under their own brand name; and (b) units manufacturing items such as rims, free-wheels, chains, spokes and nipples.

The units in category (b) are the suppliers to the small-scale assemblers, the large-scale manufacturers and the replacement market. The details of manufacturing processes and machines used by these units are given in chapter 7 and the ancillary relationship is discussed in chapter 8.

The details of manufacturing processes, the machines used and the estimated costs for a typical unit falling under category (a), with a yearly, single-shift capacity of 25,000 bicycles are given below in table 17.

Parts to be manufactured

Frames, chain stay and seat stay, fork, handle-bar, pressed parts (seat pillar, bottom ball race seating, top ball race seating, lamp bracket, brake set).

Parts to be obtained from ancillary units

Turned components, mudguards, rims, free-wheel, chain, BB shell, hubs, spokes and nipples, chain wheel and crank.

Parts to be purchased from market

Tires, tubes, bolts, nuts, screws, washers, springs, handle-bar grips, accessories, etc.

Table 17

ESTIMATED COSTS AND DESCRIPTION OF MACHINES FOR A PLANT
WITH A YEARLY, SINGLE-SHIFT CAPACITY OF 25,000 BICYCLES

<i>Description of machines</i>	<i>Unit cost (Rupees)</i>	<i>Section cost (Rupees)</i>
1. <i>Manufacturing shop</i>		205,000
One guillotine shearing machine, power operated for shearing 36 in. wide, $\frac{3}{16}$ in. thick MS sheet.	5,000	
Two double action power presses with electric motor, 60-ton capacity	30,000	

Table 17 (continued)

<i>Description of machines</i>	<i>Unit cost (Rupees)</i>	<i>Section cost (Rupees)</i>
Two power presses with electric motor, 40-ton capacity	25,000	
Two power presses with electric motor, 20-ton capacity	15,000	
One power press with electric motor, 5-ton capacity	5,000	
Two special-purpose tube cutting lathes, capacity up to 2 in. dia. pipe	12,000	
One pipe-threading machine with revolving die head for threading fork column	5,000	
One special-purpose fork collar turning machine . . .	5,000	
One hand lever shearing and bar cropping machine, up to $\frac{3}{8}$ in. dia. rods MS	1,500	
One power hacksaw with electric motor, capacity 6 in. round bar	8,000	
Two bench type drilling machines with motor, capacity $\frac{1}{2}$ in. dia. in steel	4,000	
Two pedestal drilling machines with motor, capacity $1\frac{1}{4}$ in. dia.	20,000	
Two motorized double-ended grinders, 8 in. dia. \times $\frac{3}{4}$ in. grinding wheels	3,000	
One motorized double-ended pedestal grinder, 12 in. dia. \times $1\frac{1}{4}$ in. grinding wheels	2,000	
One automatic wire straightening and cutting machine with electric motor, capacity 4 G. to 16 G. wire . .	5,000	
Two frame assembly fixtures (see figure 7)	2,000	
Two fork assembly fixtures and fork blade bending fixtures (see figure 7)	2,000	
One seat stay welding and assembly fixture	1,000	
One chain stay welding and assembly fixture	1,000	
One set of lugs for welding jigs	2,000	
Two handle-bar bending fixtures	4,000	
Two handle-bar lever bending fixtures	2,000	
Three portable electric drills, capacity $\frac{1}{4}$ in. dia. in steel	1,500	
One flexible-shaft grinder, $4\frac{1}{2}$ in. \times $\frac{3}{4}$ in. grinding wheel	1,000	
One frame testing stand	1,000	
One fork testing stand	1,000	
One handle-bar testing stand	1,000	
Hand tools measuring instruments, cutting tools. . .	10,000	
Press tools; one set of dies for each of		
frame lug brake parts		
chain stay handle-bar parts		
seat stay seat pillar		
fork parts top and bottom ball race	30,000	
2. <i>Brazing and welding section</i>		41,000
One oil-fired dip-brazing furnace with pre-heater (for frames)	10,000	

Table 17 (continued)

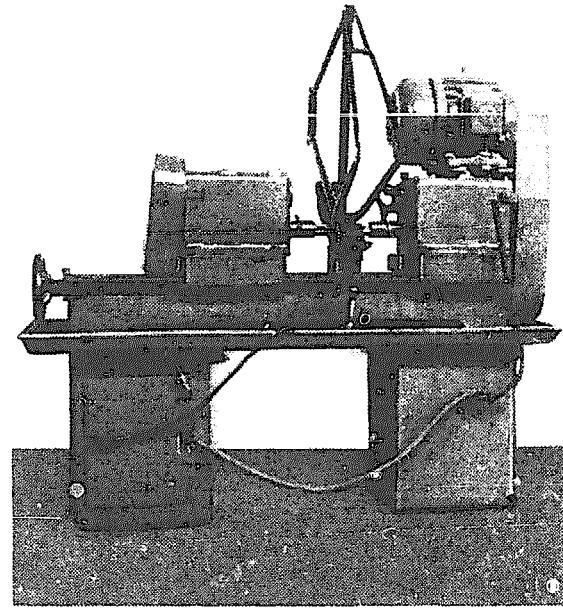
Description of machines	Unit cost (Rupees)	Section cost (Rupees)
One oil-fired dip-brazing furnace with pre-heater (for forks)	5,000	
One electrolytic de-brazing tank (for removing excess brass sticking to the brazed joint)	6,000	
Three oxy-acetylene gas welding sets with two torch sets each	12,000	
One spot-welding machine capable of welding a combined thickness of $\frac{3}{16}$ in. MS	8,000	
3. <i>Enamelling section</i>		54,000
One set of 7 bonderizing tanks	12,000	
One low-pressure vertical type steam boiler for heating tanks	8,000	
Two enamel dipping tanks and hanging jigs (one tank for primer coat and one for final coat).....	4,000	
One set of oil-fired muffle type enamelling oven with fume exhaust, thermo-couples and pyrometer for indicating stoving temperature and equipped with in and out trolleys and rail for loading and unloading components.....	30,000	
4. <i>Electroplating section</i>		67,300
(a) <i>Nickel plating outfit</i>		
One plating rectifier 7.5 volt 1000 amperes.....	12,000	
Two bright nickel-plating tanks, 8 ft × 4 ft × 3 ft MS, rubber lined	4,000	
One filter press, capacity 1000 gallons/h	6,000	
One air agitation equipment	3,500	
Three silica-clad electric immersion heaters, 5 kW...	1,500	
Two silica-clad electric immersion heaters, 3 kW ...	800	
One dull nickel plating tank, 8 ft × 3 ft × 3 ft, rubber lined	1,500	
One swilling tank, 8 ft × 3 ft × 3 ft MS, rubber lined	1,500	
(b) <i>Chromium-plating outfit</i>		
One plating rectifier 7.5 volt 1000 amperes.....	12,000	
One chromium-plating tank 6 ft × 3 ft × 3 ft, lead-lined with glass reinforcement, fitted with exhaust ..	8,000	
Two MS lead-lined tank for drag out rinse, 2 ft × 2 ft × 3 ft	1,000	
Two swilling tanks, 2 ft × 2 ft × 3 ft	1,000	
Two silica-clad electric immersion heaters, 5 kW ...	1,000	
(c) <i>Polishing shop</i>		
One double-ended polishing lathe with 5 hp motor .	2,000	
Two double-ended polishing lathes with 3 hp motor.	3,000	
Two double-ended polishing lathes with 2 hp motor.	2,500	
Exhaust to extract dust from polishing shop	6,000	

Table 17 (continued)

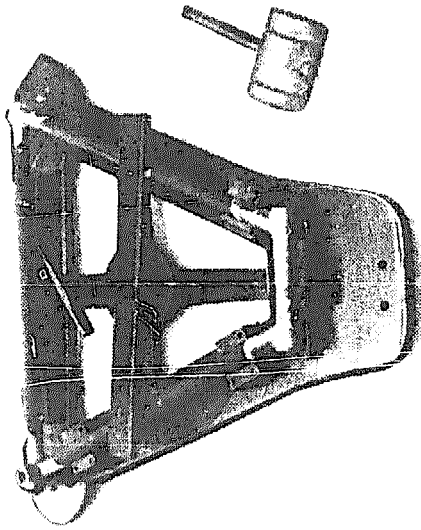
<i>Description of machines</i>	<i>Unit cost (Rupees)</i>	<i>Section cost (Rupees)</i>
5. <i>Tool room and heat treatment shop^a</i>		277,000
One heavy-duty tool room lathe with electric motor and standard equipment, length of bed 8 ft, height of centres 9 in.	40,000	
One centre lathe with electric motor and all accessories, length of bed 6 ft, height of centres 7½ in.	12,000	
One shaping machine with electric motor, universal vice and other standard accessories, length of stroke 24 in.	12,000	
One universal milling machine complete with vertical milling attachment, slotting attachment, universal milling attachment, machine vice, universal swivel vice, circular table and dividing head, table size 26 in. × 12 in.	60,000	
One pedestal-type drilling and tapping machine with electric motor, capacity in steel 1¼ in. dia.	10,000	
One bench-type drilling machine with electric motor, ½ in. dia. in steel.	2,000	
One motorized double-ended bench grinder, 6 in. dia. × 1 in. width grinding wheels	1,000	
One universal cylindrical grinding machine with standard equipment and accessories, 8 in. × 20 in. ...	30,000	
One tool and cutter grinder complete with standard equipment and accessories, 8 in. × 16 in.	15,000	
One surface grind machine complete with standard equipment and accessories, 10 in. × 27 in.	15,000	
One band sawing and filing machine with standard equipment and accessories, 16 in. dia. of saw wheel and 14 in. throat	12,000	
One transformer-type electric welding set, 30–300 amperes	4,000	
One electrical heat treatment furnace, 20 in. × 12 in. × 9 in., maximum working temperature 1400 °C.	20,000	
One tool room tempering furnace, 18 in. dia. × 20 in.	12,000	
Two quenching tanks for heat treatment.	2,000	
One Rockwell hardness tester	8,000	
Two fitting benches	2,000	
Precision instruments, hand tools and cutting tools. ...	20,000	
GRAND TOTAL		644,300

^a This room will have space for manufacture of dies etc. required by other units. A tool room with machines and equipment could be located as a common facility centre in a functional industrial estate for bicycles.

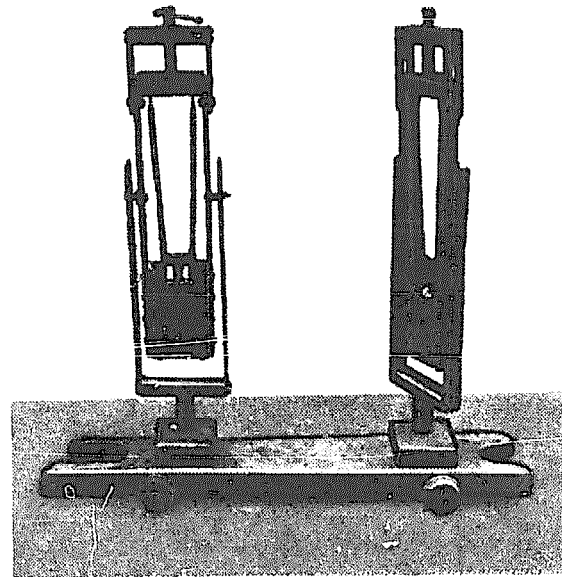
- a — Reversible spindle special-purpose tapping machine, duplex type (for threading BB shells)
- b — Frame assembly fixture
- c — Fork assembly fixture



a



b



c

Figure 7. Examples of technical innovations

PROCESS OF MANUFACTURE AND ASSEMBLY

Details of manufacturing processes for parts are given below; parts requiring similar operations are grouped together. The code number (from chapter 5) has been indicated with each part to facilitate identification.

1. Frame

Manufacturing operations

Seat tube 1002, down tube 1005, top tube 1008 and head tube 1011. Cutting tubes to length, de-burring.

Seat lug 1004, bottom head lug 1007, top head lug 1010. Cutting strips from sheets, blanking, forming, first-stage bending, inserting mandrel and second-stage bending, gas welding, grinding and cleaning, reaming holes to size.

Seat tube liner 1003, down tube liner 1006, top tube liner 1009, liner 1103. Cutting strips from sheets, blanking, bending to U-shape; inserting mandrel and bending round shape.

Riveting pins 1012. Wire straightening and cutting to length.

Chain stay tubes 1101, seat stay tubes 1201. Cutting tube to length, slitting tube end, pressing tube to oval shape and forming, inserting liners and pressing ends flat, punching slot or hole, trimming ends to shape, welding pressed ends (spot and gas welding).

Liners 1102, 1202 and 1203. Cutting strips from sheet; blanking.

Chain stay bridge 1104, seat stay bridge 1204. Cutting strips from sheet; piercing hole and blanking, bending U-shape, inserting mandrel and pressing.

Assembly of chain stay and seat stay

The LH and RH chain stay tubes and the bridges are welded together in position using the welding fixture. The fixture consists of two spacer blocks for holding the tubes of chain stay and seat stay at the correct distance at both ends and locating them, with a locating block for bridge and clamping arrangement. A trunnion arrangement for rotating facilitates welding in all positions.

The bridge is gas welded with stay tubes and the assembly is removed after the welded joint is cooled. The joint is then cleaned.

Assembly of frame

Riveting on the fixture and brazing. The frame is assembled using a fixture consisting of a locating pin and clamp for BB shell and locating V blocks with clamps for the tubes mounted on a suitable base plate.

The tube liners are inserted into their respective tubes. The top tube is assembled with seat lug, top head lug and clamped on the frame assembly fixture. The seat tube is then inserted through the seat lug into the BB shell and clamped. The bottom head lug is assembled on to down tube and this is in turn inserted into the BB shell and clamped on the fixture. The head tube is then inserted through top head lug and bottom head lug. The assembly is properly adjusted and all tubes firmly clamped. Holes are drilled through all lugs, BB shell and tube ends. Pins are inserted through these holes and riveted thus keying all tube ends with lugs and BB shell. The assembly is taken out of the fixture and the chain stay (with a dummy distance piece fixed at the hub end for maintaining the correct distance between the chain stay blades) is inserted into the BB shell lugs. A dummy seat stay is then bolted onto the frame in its proper position. This keeps the frame in the same alignment as in the final assembly during dip-brazing. After drilling and riveting the chain stay to BB shell, the frame joints

are dip-brazed. The excess brass at the joints is either filed out or de-brazed by an electrolytic method.

Finishing. The frame and seat stay are finished by stove enamelling. Various operations connected with enamelling consist of hot dip de-greasing, phosphating or bonderizing and coating with enamel by dipping. Three coats of enamel are applied; one primer coat and two finishing coats. The primer coat is stove-baked and well rubbed for roughing the surface before applying the second and final coats. After stoving the final coat, the frame and seat stay are polished and lined. Transfer labelling is applied by hand to fix the monogram on the frame.

Final assembly. Other parts such as bottom ball race seating, top ball BB axle, loose liner, steel balls, BB fixed ball cup, BB adjustable ball cup, locking ring and BB lubricator are then assembled with the frame.

2. Fork

Manufacturing operations

Fork blades 1301, 1302. Cutting strips from sheet, blanking, bending U-shape, inserting shaped mandrel in the U-bend and pressing, joint welding (gas welding), inserting bottom liner 1303, pressing end flat, slot cutting flattened end, bottom end edges welding (gas welding).

Fork blade liners 1303. Cutting strips from sheet, blanking.

Fork blade liners 1304. Cutting strips from sheet, blanking, bending U-shape, inserting mandrel and bending round.

Fork crown 1305, fork crown cover 1310. Cutting strips from sheet, blanking, drawing, trimming edges.

Box pieces 1306. Cutting strips from sheet, blanking.

Ring 1307. Cutting tube to length, de-burring.

Fork column liner 1309. Cutting strips from sheet, blanking, bending U-shape; inserting mandrel and bending round.

Assembly of fork

Welding and brazing. The fork is assembled using the fork assembly fixture. This consists of a spacing and locating block for the fork blades at the bottom end, a locating block for fork column and clamping arrangement. A trunnion arrangement facilitates tack welding in all positions.

The top liners are inserted into the fork blades which are then positioned in the fork assembly fixture and clamped. The fork crown is put over the blades and the fork column, ring and box pieces are then positioned and tack welded. The fork is removed from the fixture; a dummy distance piece is inserted between the fork blades at the bottom end. The crown joint is then dip brazed.

Excess brass sticking to the joint is removed by de-brazing. The fork blades are then bent to shape in the fork blade fixture.

Finishing. The fork is stove enamelled in the same way as the frame and lined. The crown cover is nickel and chromium plated and assembled over the fork crown.

3. Handle-bar

Manufacturing operations

Handle-bar tube 2001, handle-bar stem tube 2003. Cutting tube to length, de-burring, cutting slot at the bottom end of stem tube.

Handle-bar lug 2002. Cutting strips from sheet, blanking, drawing, trimming edges, piercing holes for draw bolt and stem tube, bending U-shape, inserting mandrel and bending round, joint welding (gas welding), cleaning the welded joint, reaming holes for handle-bar tube.

Left roller lever 2007, right roller lever 2008. Cutting rod to length; flattening ends, bending, nickel and chromium plating.

Brake tabs front 2010, brake tabs rear 2011. Cutting strips from sheet, blanking, piercing holes, forming, nickel and chromium plating.

Brake rod front 2014, brake rod rear 2015. Wire straightening and cutting to length, forming eye at one end, nickel and chromium plating.

Assembly of handle-bar

Brazing and bending. The handle-bar tube (in straight condition) and stem tube are assembled and brazed. The brazed joint is cleaned by hand filing. Holes for eye bolts are drilled. Handle-bar is bent by using the handle-bar bending fixture in two operations.

Finishing and final assembly. The handle-bar is nickel and chromium plated. The other parts such as levers, eye bolts, brake tabs, brake rods, expander cone, expander bolts and grips are then assembled with the handle-bar.

4. Pressed parts including brake parts

Manufacturing operations

Seat pillar 1019. Cutting tube to length, forming ends by pressing, nickel and chromium plating.

Bottom ball race seating 1020.

Top ball race seating 1021. Cutting strips from sheet, blanking and cupping, forming flange, piercing bottom, nickel and chromium plating.

Lamp bracket 1028. Cutting strips from sheet, piercing and blanking, bending, nickel and chromium plating.

Front brake tube 5004, rear brake tube 5016, stirrup brake tube 5030. Cutting tube to length, de-burring.

Brake stirrup 5006. Cutting strips from sheet, piercing holes, bending, forming.

Stirrup pin 5007. Wire straightening and cutting to size, de-burring, nickel and chromium plating.

Brake shoe 5008. Cutting strips from sheet, piercing hole, blanking, forming, nickel and chromium plating.

Brake clips outer 5012, brake clips inner 5013. Cutting strips from sheet, piercing and blanking, forming, bending, nickel and chromium plating.

Brake lever bottom 5019, bell crank 5025. Cutting strips from sheet, piercing and blanking, bending, nickel and chromium plating.

Bottom long brake rod 5024, bottom small brake rod 5029. Wire straightening and cutting size, forming eyes at ends, nickel and chromium plating.

Assembly of brake set

The front brake tube, brake stirrup and connector for brake tube are assembled and brazed. The brazed joint is cleaned and the part is nickel and chromium plated. All brake parts are supplied loose, but assembled at the time of selling the complete bicycle.

5. Assembly of complete bicycle

In the manufacturing unit, the complete bicycle as sold to a consumer is not assembled. The frame, fork, and handle-bar are assembled as described in this chapter. These, along with the other parts purchased from ancillary units or elsewhere, are supplied in kit form to the market. This facilitates transport and prevents damage during transit. The complete bicycle with accessories is assembled at the selling point.

MACHINES AND EQUIPMENT FOR A LOWER SCALE OF PRODUCTION

The details of machines and equipment needed for a plant with a yearly capacity of 15,000 bicycles has been listed in table 18, taking into consideration the use of cheap labour wherever economically possible. This should help the planning of bicycle manufacture in developing countries where labour is cheap and the demand for bicycles is not great. Another consideration is the limited capital investment in such countries. Machines that could be replaced by manual labour using hand tools have been omitted from the list. Similarly, wherever possible hand-driven machines have been substituted for power driven machines. Adequate care has been taken to see that quality is not affected by such replacement. Keeping capital cost low has been the chief consideration; manual labour has been suggested where it could efficiently replace an operation done by machine.

Table 18

ESTIMATED COSTS AND DESCRIPTION OF MACHINES FOR A PLANT
WITH A YEARLY, SINGLE-SHIFT CAPACITY OF 15,000 BICYCLES

<i>Description of machines</i>	<i>Unit cost (Rupees)</i>	<i>Section cost (Rupees)</i>
1. <i>Manufacturing shop</i>		102,500
One guillotine shearing machine, treadle operated for shearing 36 in. wide 16 G. sheet	3,000	
One double-action power press with electric motor, 60-ton capacity	15,000	
One power press with electric motor, 40-ton capacity	12,500	
Two double-sided heavy duty flypresses, No. 8	4,000	
Two flypresses No. 5.....	2,000	
One special-purpose fork collar turning machine ...	5,000	
One hand lever shearing and bar cropping machine, capacity $\frac{3}{16}$ in. MS sheet, $\frac{3}{8}$ in. dia. MS rod	1,500	
Two frame assembly fixtures	2,000	
Two fork assembly fixtures and fork blade bending fixtures.....	2,000	
One seat stay welding and assembly fixture	1,000	
One chain stay welding and assembly fixture	1,000	
One set of lugs for welding jigs	2,000	
Two handle-bar bending fixtures	4,000	
Two handle-bar lever bending fixtures	2,000	
Three portable electric drills, capacity $\frac{1}{4}$ in. dia. in steel	1,500	
One flexible shaft grinder, $4\frac{1}{2}$ in. \times $\frac{3}{4}$ in. grinding wheel	1,000	
One frame testing stand	1,000	
One fork testing stand	1,000	
One handle-bar testing stand	1,000	
Hand tools, measuring instruments, cutting tools. ...	10,000	
Press tools; one set of dies for each of		
frame lug brake parts		
chain stay handle-bar parts		
seat stay seat pillar		
fork parts top and bottom ball race	30,000	
2. <i>Brazing and welding section</i>		16,000
Two oxy-acetylene gas welding sets with two torch sets	8,000	
One spot-welding machine capable of welding a combined thickness of $\frac{3}{16}$ in. MS	8,000	
3. <i>Enamelling section</i>		49,000
One set of 7 bonderizing tanks	12,000	
One low pressure vertical type steam boiler for heating tanks	8,000	
Two enamel dipping tanks and hanging jigs (one tank for primer coat and one for final coat).....	4,000	

Table 18 (continued)

<i>Description of machines</i>	<i>Unit cost (Rupees)</i>	<i>Section cost (Rupees)</i>
One oil-fired muffle-type enamelling oven with fume exhaust, thermo-couples and pyrometer for indicating stoving temperature and equipped with in and out trolleys and rail for loading and unloading components.....	25,000	
4. <i>Electroplating section</i>		49,150
(a) <i>Nickel plating outfit</i>		
One plating rectifier, 6 volt 500 amperes.....	8,000	
One bright nickel plating tank, 8 ft × 4 ft × 3 ft MS, rubber lined	2,000	
One filter press, 750-gallon capacity	5,000	
One air agitation equipment	3,500	
Two silica-clad electric immersion heaters, 5 kW.....	1,000	
One silica-clad electric immersion heater, 3 kW	400	
One dull nickel plating tank, 8 ft × 3 ft × 3 ft, rubber lined	1,500	
One swilling tank, 8 ft × 3 ft × 3 ft MS, rubber lined..	1,500	
(b) <i>Chromium plating outfit</i>		
One plating rectifier, 6 volt 500 amperes.....	8,000	
One chromium plating tank 6 ft × 3 ft × 3 ft, lead-lined with glass reinforcement fitted with exhaust.	8,000	
One MS lead-lined tank for drag out rinse, 2 ft × 2 ft × 3 ft	1,000	
One swilling tank, 2 ft × 2 ft × 3 ft	500	
One silica-clad electric immersion heater, 5 kW.....	500	
(c) <i>Polishing shop</i>		
One double-ended polishing lathe with 5 hp motor .	2,000	
One double-ended polishing lathe with 3 hp motor .	1,500	
One double-ended polishing lathe with 2 hp motor .	1,250	
Exhaust fan to extract dust from polishing shop.....	4,000	
5. <i>Machine shop</i>		46,500
One centre lathe with accessories and electric motor, length of bed 6 ft, height of centres 7 ¹ / ₂ in.	12,000	
One shaping machine with electric motor and accessories, 24 in. stroke	12,000	
One pedestal-type drilling and tapping machine with electric motor, 1 ¹ / ₄ in. dia. in mild steel	10,000	
One bench-type drilling machine with electric motor, 1/2 in. dia. in steel.....	2,000	
One motorized double-ended pedestal grinder, 12 in. × 1 ¹ / ₄ in.	2,000	
One motorized double-ended bench grinder, 8 in. × 1 in.	1,500	
Precision instruments, cutting tools and hand tools...	5,000	
Fitting benches	2,000	
GRAND TOTAL		263,150

MANUFACTURE OF SPECIALIZED COMPONENTS BY ANCILLARY UNITS

The bicycle components for which individual economic units can be established are: chains; spokes, nipples and washers; mudguards; rims; hubs; free-wheel; chain-wheel and cranks; pedals; turned components; BB shells; and saddles.

The details of machinery and processes for manufacturing these items are described in this chapter.

CHAINS

Capacity and cost of plant

Capacity, one shift, 150,000 chains; total cost Rs. 500,000.

Details of plant

1. One double-arm 40-ton blanking press with coil reel and electrical accessories for blanking inner and outer plates; number of strokes per minute, 110; length of stroke, 25 mm; table size, 370×250 mm; space between arm, 540 mm; tool carrier size, 305×170 mm; strip feed maximum, 70; motor, 2 hp, 1420 rpm.

2. Four open front 20-ton piercing presses with drum feeding attachment for piercing, marking and chamfering inner and outer plates, with motor and electrical accessories; number of strokes per minute, 100; maximum up-stroke, 220 mm; adjustable stroke, 10–60 mm; depth of stroke, 160×80 mm with 32 mm and 60 mm hole size; motor 1.5 hp, 950 rpm.

3. One double-arm, double-acting 40-ton blanking and drawing press with reel and strip feeding arrangement and electrical accessories similar in specification to item No. 1 above but fitted with a 2.5 hp, 1420 rpm motor; used for blanking and drawing the collets.

4. Two horizontal coining and piercing presses with tool agitator feed for collets; number of strokes, 120 per min; motor 1.5 hp, 1420 rpm; used to flatten and punch collet bottoms.

5. Two horizontal bush-making machines with complete tools, strip feeding arrangement and reel for making bushes up to 10 mm outer dia.; number of strokes 100 per min; motor 1.5 hp, 1420 rpm.

6. One pin cropping and centring machine for pins up to 6 mm dia. \times 23 mm long; fitted with tools and run off reel, wire straightening device and mechanism for indenting pins at the end; number of strokes, 160 per min; motor 1.5 hp, 1420 rpm.

7. One pin edge rolling machine used for slight rounding of edges of the pins and to ensure uniform dia.; suitable for pins 3–8 mm dia. \times 8.25 mm long; fitted with agitator feed; complete with tools; motor 0.5 hp, 1420 rpm.

8. One single spindle automatic lathe 15 mm bar capacity for pins; to be used for connecting or locking links with spring clip fastener; standard outfit and accessories, cams, collet chuck, electric motor.

9. One tiltable, barrel-shaped retort furnace, electrically heated; maximum temperature 950°C; for carburizing and carbonitriding; flexible discharge arrangement attached to the furnace body; temperature control and standard accessories.

10. Two sets of quenching equipment consisting of two quench tanks, adaptable to the above furnace for oil or water; material collecting basket; cooling device for oil or water.

11. One salt bath, rectangular pot furnace, electrically heated; automatic temperature control; maximum temperature 650°C; working temperature 350–480°C, 24 kW (for blueing).

12. One tilting-type tumbling barrel (for de-burring chain parts) with cam-controlled lifting device and 0.5 hp motor; main drive by a 1.5 hp motor, 15–30 rpm; capacity 30 gallons.

13. Four tumbling barrels with protection hood and quick-acting door locks, octagonal shape 24 in. dia. \times 32 in. long with about 65-gallon capacity; driven by a 2 hp motor (for de-burring).

14. One Rockwell hardness tester with standard accessories.

15. Two plate stacking and sorting machines with hopper-type agitator feed; driven by 0.5 hp motor for sorting inner and outer plates and stacking into wire forks (one machine for outer plates and one for inner plates).

16. One automatic chain assembly machine with feeding devices for inner and outer plates; rollers, bushes and bearing pins, provided with tools capable of assembling $1/2$ in. pitch chains; 3 hp motor.

17. Two plate setting and riveting machines with 1.5 hp, 1000 rpm motor (used for setting the plates and the pins correctly, controlling the external width of the chain, riveting the pins and subsequently loosening the chain links).

18. Two foot presses for straight and joggled connexion links.

19. One chain proof-loading and testing machine suitable for stretching and load testing of the complete assembled chain.

20. Tools and gauges

For outer plates:

- (a) Five-fold blanking tools to be used with machine No. 1;
- (b) Interchangeable piercing, chamfering and marking on tool to be used with machine No. 2;
- (c) Two-fold blanking tool for connecting link to be used with machine No. 1;
- (d) Piercing tool for connecting link to be used with machine No. 2.

For inner plates:

- (a) Five-fold blanking tool to be used with machine No. 1;
- (b) Interchangeable piercing tool to be used with machine No. 2;
- (c) For spring clips: multi-stage tool for the lock spring of connecting link to be used with machine No. 1;
- (d) For rollers: five-fold blanking drawing tool for roller cups (collets) to be used with machine No. 1;
- (e) Flattening and piercing tool for collets to be used with machine No. 4.

For bushes:

- (a) Cutting-off and end-forming tool to be used with machine No. 5;
- (b) General tools and instruments;
- (c) One set of gauges for controlling chain parts dimensions.

Manufacturing operations

Inner plates 6201, outer plates 6204. Multiple blanking from strip, de-burring, piercing, de-burring, blueing.

Bushes 6202. Cutting strips, curling over mandrel, heat treating.

Rollers 6203. Blanking from strip and cupping, flattening bottom, piercing bottom, de-burring and heat treating.

Bearing pins 6205. Wire straightening and cutting to size, indenting ends, rolling, heat treating.

Spring clip 6206. Blanking, piercing and blueing.

Connecting pin 6207. Turning and cutting to size, heat treating.

Assembly of chain

The inner and outer links are automatically sorted and stacked on wire forks through a plate stacking and sorting machine fitted with hopper feed. The chain is then assembled on an automatic chain assembly machine. It is riveted by a special plate setting and riveting machine.

SPOKES, NIPPLES AND WASHERS

Capacity and cost of plant

Capacity, 80,000 gross per year; cost approximately Rs. 250,000.

Details of plant

1. One automatic universal spoke machine, suitable for manufacturing bicycle spokes up to 12 $\frac{1}{2}$ in. long \times 13 G.; complete with gear box, fly wheel, V belts, built-in clutch device, wire straightening and cutting device, equalizing device, head upsetting and bending stages, thread rolling mechanism, built-in counter and automatic lubrication, electric motor, switch gear, etc.

2. One automatic nipple blank machine (horizontal single stroke: cold header) with wire straightening and feeding rollers, pressurized automatic lubrication, built-in counter, header die, ejector pin, electric motor and switch gear; capable of forming nipped blanks from brass wire up to 4 G.

3. One automatic nipple finishing machine suitable for drilling, threading square milling slotting nipple blanks in ten stages; complete with hopper feed system, magazine, blank holder jaws, gear box, automatic lubrication, indexing mechanism, electric motors, switch gear and other accessories.

4. One automatic power press, eccentric type, with auto-roll feed system and electric motor.

5. *Electroplating equipment*

- (a) Either one motor generator or one rectifier set for supplying power at 12 volt, DC 250 amperes with ammeters, voltmeter and regulator;
- (b) Two barrel plating equipments for electroplating wire spokes with reduction gear, non-metallic barrel of round cross section, pulleys, connectors, immersion heaters; complete in all respects for bright electroplating spokes;
- (c) Two barrel plating outfits for electroplating brass nipples and washers;
- (d) Two electroplating outfits for copper-plating brass nipples and washers;
- (e) One de-greasing equipment;
- (f) One drying centrifuge for nipples and washers.

Manufacturing operations

Spokes 3002 and 4002. Wire straightening and cutting to length, upsetting head, head bending, thread rolling and electroplating.

Nipples 3003 and 4003. Cold heading and cutting, drilling, tapping, milling (square), slotting and electroplating.

Washers 3007 and 4004. Piercing, blanking, forming and electroplating.

MUDGUARDS

Capacity and cost of plant

Capacity, 150,000 per year; cost, approximately Rs 150,000.

Details of plant

1. One power driven guillotine shearing machine 48 in. \times 16 G.
2. One double roll strip roller with electric motor.
3. One hopper for automatic feeding of sized strips to the gang punching press.
4. One gang punching press with electric motor.
5. One mudguard rolling machine with roller feed arrangement and electric motor.
6. Two power presses with electric motor; 15-ton capacity.
7. One spot-welding machine for welding a maximum combined thickness of $\frac{3}{16}$ in.
8. One gas welding set.
9. One wire straightening and cutting machine; capacity up to $\frac{1}{4}$ in. dia. wire.
10. One automatic thread rolling machine with feeding arrangement.
11. One set of de-greasing and phosphating tanks.
12. One oil-fired muffle furnace for stove enamelling with temperature control and trolleys.
13. One set of dipping tanks for enamelling.

Manufacturing operations

Rear mudguard 1030, front mudguard 1036. Cutting strips from sheet, piercing holes, bead rolling, rolling mudguard, folding ends and forming reflector seat.

Rear mudguard inner bridge 1031, front mudguard inner bridge 1037. Cutting strips from sheet, piercing and blanking, and forming.

Rear mudguard stays 1032, front mudguard stays 1038. Wire straightening and cutting, de-burring, and thread rolling.

Rear mudguard tabs 1033, front mudguard tabs 1039. Cutting strips from sheet, piercing and blanking, forming and bending.

Clip 1035. Cutting strips from sheet, blanking and forming.

Assembly and finishing

The inner bridges and clips are spot welded with rear mudguard and front mudguard. Tabs are assembled over stays and tack- and gas-welded. All components are phosphated and stove enamelled.

RIMS

Capacity and cost of plant

Capacity, 100,000 per year; cost, approximately Rs. 300,000.

Details of plant

1. One power-operated rotary shearing machine with electric motor; capacity, 10 G.
2. One strip rolling and cutting machine with motor.
3. One rim rolling machine with one set of rollers for forming the bead and another set for forming the rim section with motor.
4. One rim cutting press with motor.
5. One butt welding machine.
6. One rim weld joint grinder inside and one for outside.
7. Two seam welding machines.
8. One rim re-rolling machine.
9. Three power presses with motor, 10-ton capacity.
10. One rim load testing fixture.
11. Four rim polishing lathes.
12. One set of electroplating equipment for bright nickel and chromium plating.

Manufacturing operations

The manufacture of the rims has been described in chapter 4.

HUBS

Capacity and cost of plant

Capacity, 50,000 pairs of hubs per year; cost, approximately Rs. 300,000.

Details of plant

1. One double-action power press with motor; 75-ton capacity.
2. Two power presses with motor; 50-ton capacity.
3. Two power presses, with motor; 25-ton capacity.
4. One single-spindle automatic lathe, 1 in. capacity.
5. Five single-operation lathes with collet attachment, motorized; 1 $\frac{1}{2}$ in. capacity.
6. Two drilling machines with motor; 1 $\frac{1}{2}$ in. capacity.
7. One special purpose single-operation lathe with rotating spindle at both ends and fixed central vice to turn two ends of tube simultaneously.
8. One milling machine, horizontal bench model with motor and accessories.
9. One tapping machine; 1 $\frac{1}{2}$ in. capacity.
10. One thread-rolling machine with motor; 1 $\frac{1}{2}$ in. capacity.
11. Five arbor presses, 1-ton capacity.

12. One marking press, hand operated.
13. One hand fly press No. 6.
14. One guillotine shearing machine, power operated, 36 in. × 10 G.
15. One bar-cropping machine, power operated; 1/2 in. capacity.
16. One toolroom lathe 6 ft, with motor.
17. One shaping machine with motor; 18 in. capacity.
18. One pillar-type drilling machine, with motor; 1 in. capacity.
19. One bench-type drilling machine with motor; 1/2 in. capacity.
20. One bench-type vertical milling machine with dividing head and motor.
21. One tool post grinder, motorized; 6 in. wheel.
22. One double ended grinder bench-type, motorized; 8 in.
23. Salt bath furnace for case-hardening cones and cups, temperature 950°C; depth of pot 24 in., dia. of pot 24 in.; with preheater temperature 600°C.
24. One set of electroplating equipment with polishing lathes for bright nickel and chromium plating.
25. Tools, equipment, fixtures.
26. Precision instruments, gauges, hand tools.

Manufacturing operations

Rear hub shell 3101, front hub shell 4101. Cutting tube to length, deburring, turning internal and outside diameter, punching oil hole, marking.

Distance piece 3102. Cutting strips from sheet, blanking, bending U-shape, inserting mandrel, bending round.

Rear hub ball race cups 3103, front ball race cups 4102. Cutting strips from sheet, blanking, drawing cup, punching bottom, turning outside diameter, facing collar, heat treating and polishing with emery paste.

Spoke flanges rear hub 3104, spoke flanges front hub 4103. Cutting strips from sheet, blanking, drawing cup, flattening flange, punching bottom, turning flange rim, facing flange, punching holes (for spokes), counter-sinking holes, threading (right hand flange of rear hub only).

Rear hub axle 3105, front hub axle 4104. Cutting rod to length, chamfering ends, thread rolling, rust-proofing chemically.

Fixed cone rear hub 3107, adjustable cone rear hub 3108, fixed cone front hub 4105, adjustable front hub 4106. Drilling, form turning ball race, cutting off to size, chamfering, tapping thread, milling flats, marking, heat treating, rust-proofing chemically.

Dust cap washer rear hub 3109, dust cap washer front hub 4108. Cutting strips from sheet, punching hole and blanking.

Oil clip rear hub 3112, oil clip front hub 4111. Cutting strip, blanking, bending, hardening, tempering and blueing.

Chain adjuster rear hub 3113. Cutting bar to length, chamfering one end, stamping other end, punching eye hole, thread rolling.

Chain adjuster clips rear hub 3114. Cutting strips from sheet, punching hole and blanking, forming.

Assembly of hubs

The distance piece is inserted into the hub shell (in case of rear hub only). The ball race cups are pressed in, at both ends of hub shell. The spoke flanges are pressed on the hub shells at both ends. The axle is thereafter inserted. steel balls are filled in and cones assembled. The dust caps are pressed in and electroplated. Nuts, washers, spring clips are then fitted.

FREE-WHEEL

Capacity and cost of plant

Capacity, 100,000 free-wheels per year; cost, approximately Rs. 400,000.

Details of plant

1. One double-sided stamping press with electric motor; 100-ton capacity.
2. One power press with electric motor; 50-ton capacity.
3. One power press with electric motor; 10-ton capacity.
4. One drop hammer with electric motor; $1/2$ -ton capacity.
5. One oil-fired furnace for use with drop hammer.
6. Eight single-operation chucking lathes for facing and turning with electric motor; chucking capacity 4 in.
7. Three special purpose threading lathes with reversible spindle with electric motor; chucking capacity 4 in.
8. One vertical ram-type bench milling machine with electric motor and accessories.
9. One vertical ram-type bench milling machine with motor and accessories.
10. One rotary surface grinder, dia. of work table 20 in.; with motor and accessories.
11. One bench drilling machine with motor; $1/2$ in. capacity.
12. One salt bath carburizing furnace, temperature 900°C ; dia. of pot 24 in., depth of pot 24 in.; with preheater.
13. One muffle-type annealing and tempering furnace, temperature 650°C ; size of chamber 12 in. \times 10 in. \times 24 in.
14. One Rockwell hardness tester.
15. One hand-operated screw press for marking.
16. One vertical-type broaching machine, capacity of $2\frac{1}{2}$ in. dia. internal broaching.
17. Tools and dies, other equipment and fixtures.
18. Precision measuring instruments and hand tools.

Manufacturing operations

Free-wheel body 3201. Hot punching hole, drop forging to shape, annealing, one side facing, boring internal diameter, second side facing, turning outside diameter, milling slot, milling all seating, threading, rust-proofing chemically. (The material used for this is the slug obtained from hot punching of sprocket wheel blank.)

Sprocket wheel 3202. Hot blanking and punching, drop forging to shape, annealing, boring internal diameter, turning outside diameter, one side facing, second side facing, finishing teeth flange, machining ball grooves, punching sprocket teeth, shaving teeth, broaching internal teeth, heat treating, rust-proofing chemically.

Free-wheel pawls 3203. Blanking, drilling, heat treating.

Pawl pin 3204. Cutting wire to size.

Pawl spring 3205. Blanking, forming, heat treating.

Pawl washer 3205 (a). Blanking, de-burring.

Free-wheel cones 3207. Blanking, punching internal diameter, drop forging to shape, annealing, surface grinding, boring, internal threading, drilling pin-spanner holes, turning and finishing outside diameter, marking, heat treating, rust-proofing chemically.

Assembly of free-wheel

In assembling the free-wheel, one of the free-wheel cones is riveted to the free-wheel body. The free-wheel pawl is then fixed with pawl pin spring and washers. Balls and the other cones are assembled thereafter.

CHAIN WHEEL AND CRANKS

Capacity and cost of plant

Capacity, 100,000 pieces per year; cost, approximately Rs. 350,000.

Details of plant

1. One guillotine shearing machine, 48 in. \times $\frac{3}{16}$ in. thickness, with electric motor.
2. One power hacksaw with electric motor; 6 in. dia. round capacity.
3. One power press with motor; 100-ton capacity.
4. One power press with motor; 60-ton capacity.
5. One oil-fired furnace; 3 ft \times 2 ft \times 18 in. for forging.
6. One pneumatic hammer with motor; $\frac{1}{4}$ -ton capacity.
7. One drop-forging hammer, with motor; 1-ton capacity.
8. One oil-fired muffle-type annealing furnace, 3 ft \times $1\frac{1}{2}$ ft \times 2 ft depth.
9. One set of sand-blasting equipment.
10. One drilling and tapping machine geared, with motor; 1 in. capacity.
11. Four single-operation special purpose lathes for turning and facing.

12. One set of electroplating equipment with polishing lathes for bright nickel and chromium plating.
13. Tools, dies, equipment, fixtures.
14. Precision instruments, hand tools, gauges.

Manufacturing operations

Chain wheel 6001. Cutting strips from sheet, punching centre hole, blanking, forming joggle, punching design and trade name, punching sprocket teeth.

RH crank 6002, LH crank 6007. Cutting bar to length, pre-forging to rough shape, drop forging to shape, annealing, sand-blasting and cleaning, drilling centre holes, turning and facing both sides, tapping, drilling cotter hole.

Assembly of chain wheel and cranks

The RH crank is riveted to the chain wheel; this is then electroplated with the LH crank.

PEDALS

Capacity and cost of plant

Capacity, 100,000 pairs of pedals per year; cost, approximately Rs. 180,000.

Details of plant

1. One power-operated guillotine shearing machine, 36 in. \times 10 G.
2. One power hacksaw machine; 6 in. round capacity.
3. One power press; 40-ton capacity.
4. One single operation special purpose tube cutting lathe with motor; 1 in. capacity.
5. One single spindle automatic lathe with motor; 1 in. capacity.
6. One drilling and tapping machine pedestal-type, with motor; 1 in. capacity.
7. One special purpose lathe with collet attachment, 4-way tool post and self opening die-head on tail-stock; collet capacity $3\frac{1}{2}$ in.
8. One special purpose lathe with collet attachment, 4-way tool post and self opening die-head on tail stock; collet capacity 1 in.
9. One milling machine bench-type, with motor and accessories.
10. One pneumatic hammer with die-forging attachment; 1 cwt capacity.
11. One oil-fired furnace, 2 ft \times 1 ft \times $1\frac{1}{2}$ ft depth.
12. One oil-fired salt bath carburizing furnace, temperature 950°C , 2 ft depth \times 18 in. dia. of pot; with preheater temperature 600°C .
13. One set of electroplating equipment with polishing lathes for bright nickel and chromium plating.
14. Tools, dies, equipment, fixtures.
15. Precision instruments, gauges, small tools.

Manufacturing operations

Pedal tubes 6101. Cutting tube to length, de-burring, electroplating.

Ball-races 6102. Cutting strips from sheet, blanking, drawing cup, punching bottom, heat treating, polishing.

Stretcher bars 6104. Turning one end, threading, cutting off, turning other end, threading.

Pedal plates 6105. Cutting strips from sheet, punching holes, blanking, de-burring, electroplating.

Pedal axles 6107. Cutting bar to length, forging to shape, annealing, turning, threading, milling flats, milling slot, heat treating, rust-proofing chemically.

Pedal cones 6108. Drilling, form turning ball race, cutting off, tapping, milling flats, heat treating, rust-proofing chemically.

Winged dust caps 6111. Cutting strips from sheet, blanking, drawing and forming, punching hole, electroplating.

Assembly of pedals

The ball race cups are pressed into the pedal tube. Pedal axle is inserted into the pedal tube and steel balls are put in; the cone is screwed on. The pedal plates, winged dust cap, stretcher bars, rubbers and nuts are then assembled.

TURNED COMPONENTS

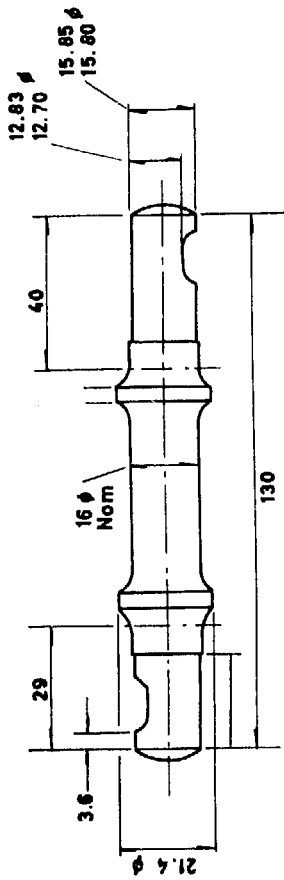
The items for which the plant details have been given in figure 8 are: crown race 1022; bottom inner ball race 1024; top inner ball race 1025; screwed race 1026; locking nut 1029; BB axle 1044; BB fixed cup 1047; BB adjustable ball cups 1048; locking nut 1049; cotter pin 6003; washer 6004; nut 6005; and spring washer 6006.

Capacity and cost of plant

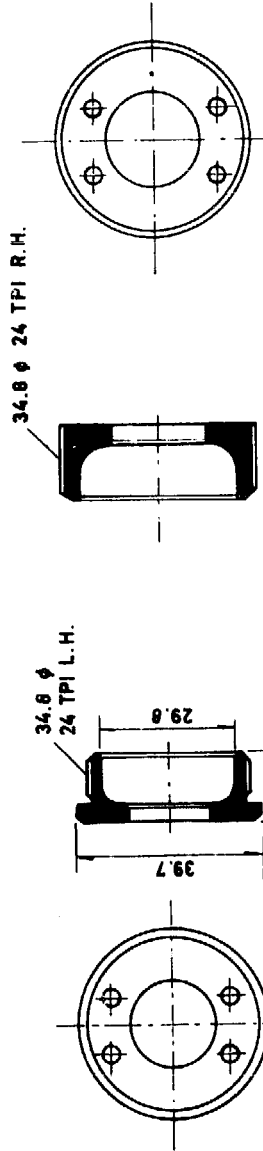
Capacity, 60,000 sets of turned components per year; cost, approximately Rs. 500,000.

Details of plant

1. One single spindle automatic screw machine with accessories; 2½ in. bar capacity.
2. Two single spindle automatic screw machines with accessories; 2 in. bar capacity.
3. One milling machine, bench-type, with accessories and motor.
4. One drilling machine, bench-type, with motor; ½ in. capacity.
5. One automatic cycle, centreless grinding machine, maximum work dia. 2 in. with hopper feed attachment.
6. One hydraulic marking press.
7. Two oil-fired salt bath furnaces; 2 ft dia. × 2 ft depth, temperature 950°C, with preheater temperature up to 600°C.

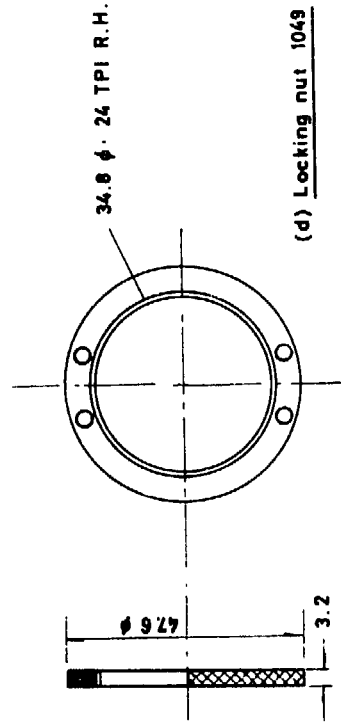


(a) BB Axle 1044

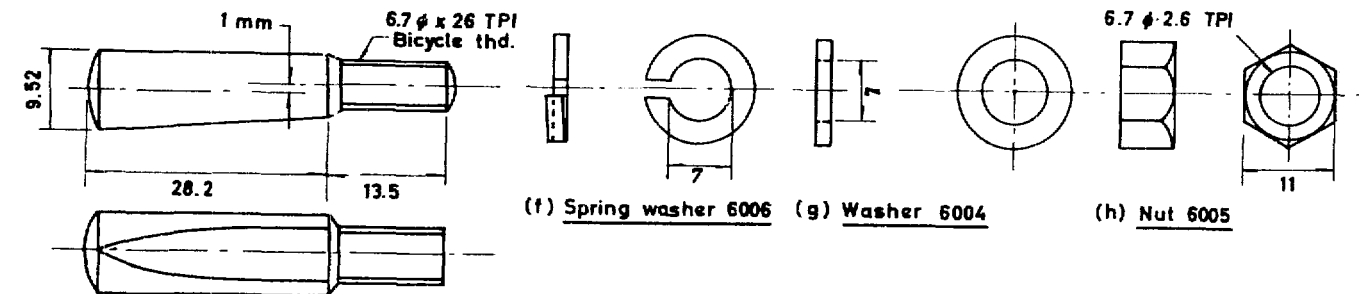


(b) BB Fixed cup 1047

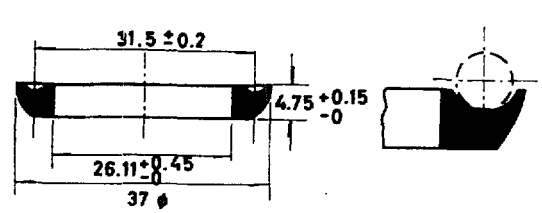
(c) BB Adjustable ball cup 1048



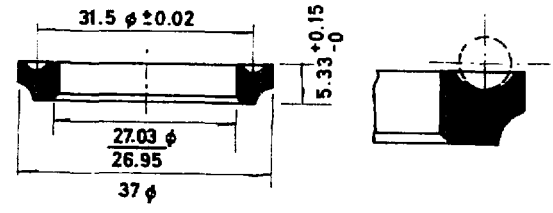
(d) Locking nut 1049



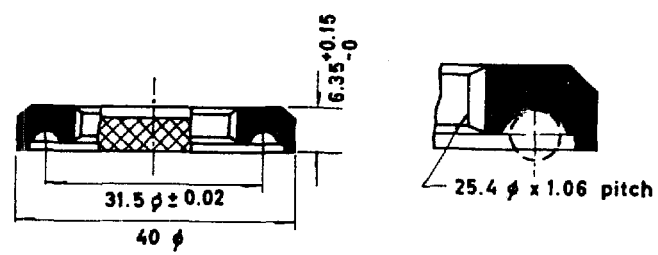
(e) Cotter pin 6003



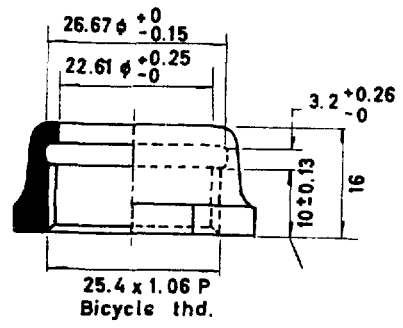
(i) Top and bottom inner ball race 1024, 1025



(j) Crown race 1022



(k) Screwed race 1026



(l) Locking nut 1029

Figure 8. Turned components

8. One Rockwell hardness tester.
9. One barrel plating equipment for bright nickel and chromium plating.
10. One centre lathe, 6 ft length of bed, 6 $\frac{1}{2}$ in. height of centres; motorized with accessories.
11. One tool and cutter grinder, 8 in. \times 16 in.; attachments.
12. One tool grinder for carbide tipped tools.
13. Precision instruments, gauges and tools.

Manufacturing operations

All the parts are machined. Heat treatment is given to all parts except spacing washer, locking nut and locking ring which are electroplated after machining. BB axles are ground after heat treatment. All heat-treated parts are rust-proofed chemically.

BB SHELLS

The bottom bracket shells are generally of malleable cast iron. The unmachined castings are bought from specialized malleable iron foundries, because it is not economical to set up a small capacity malleable iron foundry for the production of BB shells.

Capacity and cost of plant

Capacity, 100,000 BB shells per year; cost, approximately Rs. 80,000.

Details of plant

1. One special purpose chamfering and facing lathe with work holding fixture in the centre for clamping BB shell.
2. Two special purpose horizontal drilling machines, duplex type, with central work holding fixture.
3. Two reversible spindle special purpose tapping machines, duplex type, with central holding fixture. (See figure 7.)
4. Two drilling machines, pedestal type; 1 $\frac{1}{2}$ in. capacity.
5. One drilling and tapping machine, bench-type; $\frac{1}{2}$ in. capacity.
6. Tools, equipment, fixtures.

Manufacturing operations

The unmachined casting is clamped on the chamfering machine and the two ends are faced and chamfered. It is then mounted on the duplex drilling machine and both ends are drilled. On the tapping machine both ends are thereafter threaded (right hand and left hand).

The other holes into which frame tubes are fitted are drilled and reamed on the pedestal-type drilling machine. The hole for the oil cup is drilled and tapped on the bench-type drilling and tapping machine.

SADDLES

Capacity and cost of plant

Capacity, 40,000 saddles per year; cost, approximately Rs. 150,000.

Details of plant

1. One power-operated leather splitting machine, 24 in. width.
2. One hydraulic leather clicking press, 8 in. stroke; motorized.
3. Two hydraulic moulding presses, 8 in. stroke platen size 16 in. × 16 in. with pump motor and electrical heating arrangement; 80-ton capacity.
4. Two leather-buffing and finishing machines with exhaust.
5. One spring coiling machine.
6. One air compressor with spraying equipment.
7. One guillotine shearing machine, 36 in. × 10 G., power operated.
8. One power press; 40-ton capacity.
9. One set of electroplating equipment for bright nickel and chromium plating with polishing lathes.
10. One hand lever rod cropping machine up to $\frac{3}{8}$ in. dia. of rod.
11. Wire bending fixtures.
12. Tools, dies, instruments, brass moulds.

Manufacturing operations

The leather is split in the splitting machine for uniform thickness. Saddle blanks are cut on the clicking press. The saddle tops are moulded in the hydraulic moulding press with electrically heated moulding dies. The holes are then punched and saddles coloured, buffed and finished. The sheet metal and wire parts are made on the other machines and electroplated. The saddle top and other parts are then assembled.

BICYCLE ACCESSORIES

Besides the various parts and components discussed in this chapter and earlier, several accessories are required for bicycles. Economically viable units for each of such accessories can be set up in the small-scale sector. The accessories used are of several types, designs and specifications. Complete details of these accessories, their manufacture, plants, machinery required and so on are beyond the scope of this paper and would provide the subject matter for another paper. However, a list of accessories and various types and designs is given below:

1. Luggage carrier
 - (a) solid steel wire frame with stays and spring grip and foldable side wings
 - (b) pressed steel frame with rod stays
 - (c) strip steel frame and rod stays
 - (d) steel tube frame with tubular stays and spring grip

2. Single side stand
 - (a) single side stand with rod prop
 - (b) single side stand with pressed steel prop
3. Centre stands filled either to hub spindle or chain stay neck
 - (a) rod prop type
 - (b) pressed steel type
4. Double side stands
 - (a) pressed steel, pick-up type with spring lock
5. Gear cases or chain covers
 - (a) full gear cases
 - (b) half gear cases
 - (c) quarter chain covers
6. Cycle bells
 - (a) double dome-type chime bell, brass or steel
 - (b) ding-dong bell, single dome brass or steel
 - (c) spoke bells
7. Air horns
 - (a) straight air horn with rubber bulb and metal clip
 - (b) double note air horn
8. Electric siren horns
9. Fork guards
 - (a) straight pattern
 - (b) curved pattern
10. Lighting sets
 - (a) electric dynamo lighting set, 12-volt or 6-volt types
 - (b) dry battery type electric lighting sets
 - (c) oil lamps
11. Mud flaps
 - (a) plastic
 - (b) rubber
12. Back reflecting mirrors
13. Pumps
 - (a) foot pumps
 - (b) frame pumps
14. Locks
 - (a) side locks for front or rear wheel
 - (b) ring locks
 - (c) combination chain or cable locks

15. Mascots
 - different shapes
16. Rear reflectors
17. Touring bag and baskets
18. Cycle tools
 - (a) spanners
 - (b) eight-way box wrench
 - (c) spoke wrench
 - (d) pliers
 - (e) tire lever
 - (f) gear puller
 - (g) handle-bar puller
 - (h) wheel building stand
19. Trade mark label plates

THE SUBCONTRACTING SYSTEM AND THE FUNCTIONAL INDUSTRIAL ESTATE FOR THE BICYCLE INDUSTRY²

The details of manufacture of a complete bicycle have been discussed in chapter 6, and the manufacture of components in ancillary units is discussed in chapter 7. This chapter considers the subcontracting system in reference to ancillary relationships between large- and small-scale firms and joint production programmes in functional industrial estates. To obtain a clear concept of these relationships, it is necessary to review the general aspects of these systems.

THE SUBCONTRACTING SYSTEM

General concept

Because of its decentralized character, the subcontracting system has techno-economic advantages, helping the over-all development of industries. Under this system, several economically viable small-scale units are set up to make the components, parts and sub-assemblies required in the end product. The small-scale units may work either in the same area as the large-scale unit or elsewhere. Some large-scale units have established ancillary industrial estates to accommodate subcontracting units.

Advantages

The main advantages of the subcontracting system are: (a) All parts and components required for the end product need not be produced under one roof by a large-scale unit. (b) A complex organization both from the technical and administrative points of view is not required by the large unit. This minimizes many problems such as labour unrest. (c) The risks of business fluctuations and obsolescence of machinery are minimized; modernizing the plant is possible without many problems. (d) Research and quick adoption of new technology allow greater specialization by subcontracting units. (e) Entrepreneurial talent and the latent financial resources can be better tapped in ancillary units. (f) Large-scale units are in a position to concentrate on sophisticated items where greater skill and investment are necessary.

² Subcontracting and ancillary are used as synonymous words in India.

Methods of negotiations and the role of the government

Under the subcontracting system, ancillary units make direct negotiations with the large-scale units for supply of components. In some cases proprietors of subcontracting firms were either working in some section of the main industry or are otherwise known to the large firms. These relationships serve as an indirect means to create the confidence of the large firms in the ancillary units. The large-scale firms provide designs, drawings and standard specifications to the subcontracting units and sometimes help to supply them with raw materials. Inspection of components in ancillary units is also done by the large firms both during and after manufacture. It is, however, necessary for the government to play a positive role and establish policies for the development of ancillary industries so that they may have a continued relationship and proper assistance from the large units. Otherwise, if the large-scale units start producing parts themselves or break contracts, the ancillary units may suffer badly.

Requirements of ancillary units

There are certain requirements for the proper development of small subcontracting units. Parent units must offer long-term contracts and provide technical know-how, designs, drawings and so on to the small-scale units. Payment should be made to small-scale units on time. If payments are delayed or if contracts are not on a long-term basis, the ancillary industries may suffer greatly. On the other hand, for the proper functioning of ancillary units it is also necessary that competent entrepreneurs be given the subcontracts.

Ancillary development in India

The Ancillary Industries Development Programme has been in force on a regular basis in India since 1960 and it has been proved that the role of these industries in the industrial development of the country is vital. In India, an ancillary industrial unit is defined as follows:

“Unit which produces parts, components, sub-assembly and tooling for supply against known or anticipated demand by one or more large-scale units manufacturing or assembling complete products and which is not a subsidiary to or controlled by any large-scale unit in regard to the negotiations of contract for supply of its goods to any large-scale unit. This shall not, however, preclude an ancillary unit from entering into an agreement with a large-scale unit giving it the first option to take over the former's output.”

Units set up primarily for the replacement market also fall within this definition. Normally a small-scale unit is one in which the investment in the form of machinery and equipment does not exceed Rs. 750,000, irrespective of the number of workers employed. For an ancillary small-scale unit the ceiling of investment on machinery and equipment is Rs. 1 million. This higher ceiling of investment entitles a small-scale ancillary unit to take advantage of numerous facilities from governmental and non-governmental agencies, including:

- (a) Technical assistance from the Central Small Industries Organization through the Small Industries Service Institutes and extension centres located in every state in India.
- (b) Supply of machinery under the hire-purchase scheme of the National Small Industries Corporation, a Government of India undertaking. This corporation provides machines on a hire-purchase basis after an initial payment of 20 per cent of the cost of the machine, the balance paid in instalments over a period of five to seven years.
- (c) Allotment of factory sheds in the industrial estates.

Sixteen types of industry including the bicycle industry have been selected for development of ancillary industrial units in India. This indicates that the Government of India has recognized the potential of ancillary development in the bicycle industry. It has also set up a special ancillary committee that co-ordinates the work of large-scale units with that of small-scale ancillary units. Since 1962 many subcontracting units have been developed with the assistance given by the central and state Government.

FUNCTIONAL INDUSTRIAL ESTATES

A functional industrial estate is set up for the production of a particular item, with several ancillary units forming a cluster around the central unit. Under this scheme the small-scale ancillary units supply manufactured parts and components to the central unit. The advantage is that several ancillary units in one industrial estate can conveniently share facilities such as tool rooms and testing laboratories³. It is also easy to supply raw materials to the units and collect finished goods. The inspection and quality control of products also become easier.

SUBCONTRACTING IN THE BICYCLE INDUSTRY⁴

The bicycle industry offers excellent opportunity for subcontracting. In India, this industry is well established on these lines and there is a close relationship between, on the one hand, the large- and small-scale units manufacturing complete bicycles, and on the other hand, the ancillary units. The ancillary units produce about 75 per cent of the complete bicycle and also supply the replacement market.

³ Joint production programmes may also be organized for small-scale industries located outside of an industrial estate. They are, however, particularly effective when organized within a functional industrial estate. A publication on the organization of functional industrial estates is being prepared by the secretariat of UNIDO.

⁴ The subcontracting system in Japan is of interest since a large number of small-scale units have been developed under this system. Subcontracting units receive a regular flow of raw material, are assured of markets for their products, and can obtain guidance and even financial assistance from the parent companies. This makes it possible for subcontracting units to manufacture parts at low cost. It is estimated that about 75 per cent of the bicycle manufacturing industry in Japan falls under subcontracting. There are certain disadvantages

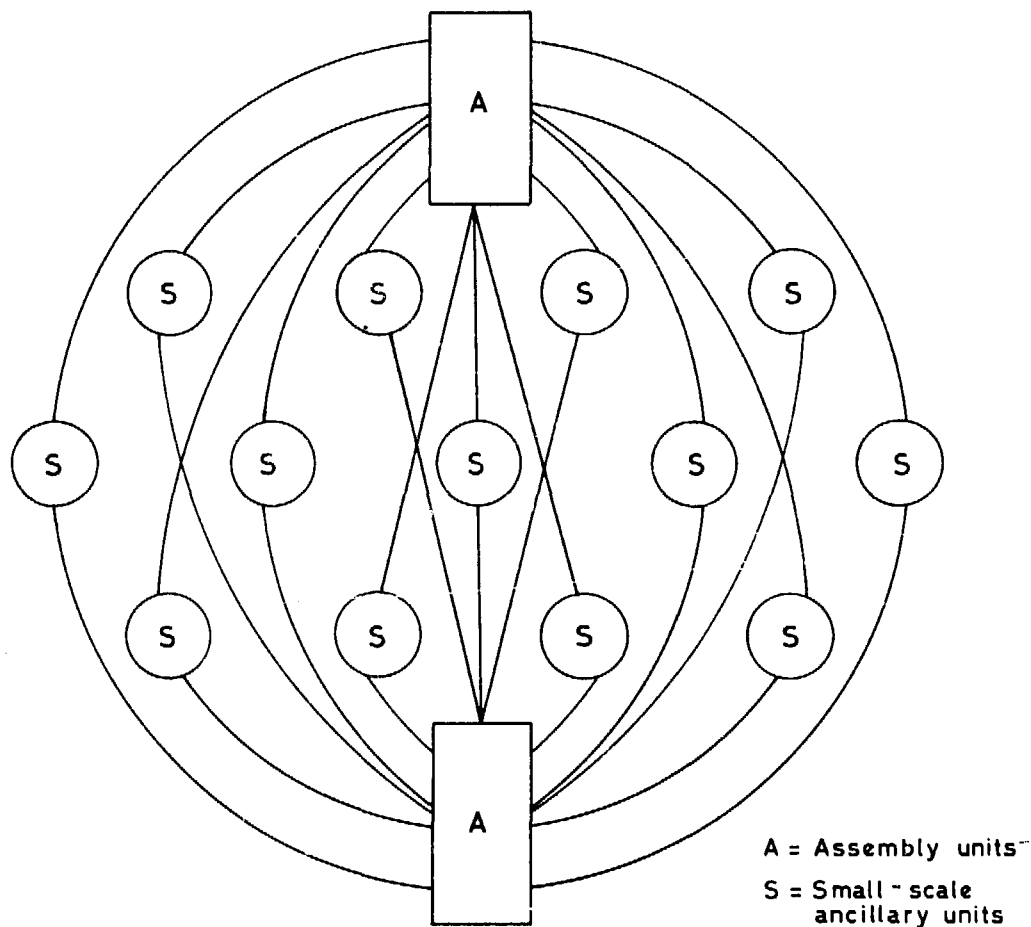


Figure 9. Diagram of subcontracting relationship between large- and small-scale units

Three types of plan for setting up bicycle units both in the large-scale and small-scale sectors, using subcontracting and the functional industrial estate, are discussed below. The raw materials required, manufacturing processes, plants and equipment necessary for all parts and components have been stated under chapters 5, 6 and 7.

- Plan A. Setting up large-scale units using subcontracting
- Plan B. Setting up small-scale units using subcontracting
- Plan C. Setting up a functional industrial estate for bicycle manufacture

to this system because the parent enterprises generally exercise a dominant role over the subcontractors, are prone to determine for their own advantage prices, terms of payment and other dealings, and resist long-term contracts. Subcontracting units may be exposed to a reduction of their profit without notice and to delayed payments. To safeguard the interests of subcontracting units, the Government of Japan has passed laws whereby parent companies must sign written contracts and make payments for deliveries within a specified time. The Government has helped subcontractors to develop and modernize their units by supplying them with: technical assistance and guidance by teams of experts, special training for managers of subcontracting units, and machinery for modernization and improvement of quality.

Plan A. Setting up large-scale units using subcontracting

1. Output of bicycles per year for each plant: 150,000 men's bicycles; 25,000 women's bicycles; 25,000 sports model bicycles.
2. Items to be manufactured in the factory: frames, forks, chain stays, seat stays, pressed parts; turned parts; handle-bars, mudguards, hubs, free-wheels.
3. Items to be obtained from ancillary units: rims, chains, pedals, spokes and nipples, BB shells, chain wheel and cranks, saddles.
4. Items to be purchased from specialized manufacturers⁵: tires and tubes, steel balls.

Figure 9 illustrates this relationship.

For an adequate supply of a particular item, a large-scale unit may have to place orders with more than one ancillary unit. On the other hand, the ancillary units may supply items to more than one large-scale unit; this is advantageous to both. The large-scale units receive the benefit of competitive price and are assured a regular supply of components as they have more than one ancillary supplier. Similarly the ancillary units do not depend only on one large-scale unit for orders but can obtain a good price for quality products from several large-scale units.

The disadvantage of the above system is that large-scale units can suddenly stop their orders to the ancillary units. Also, ancillary units may hamper the production programme of large-scale units by not supplying components on schedule. To overcome this drawback, both units must enter into a firm contract for a sufficiently long period of time.

Location. The large units may be set up near metropolitan cities which are the main marketing centres. Ancillary units may be dispersed within a radius of 100 kilometres to take advantage of cheap labour, land and locational benefits.

Plan B. Setting up small-scale units using subcontracting

Output of bicycles per year for the plant: 15,000 men's roadster bicycles (single bar); 5,000 men's roadster bicycles (double bar) and carrier model; 3,000 women's roadster bicycles; 2,000 children's bicycles.

Items to be manufactured in the factory, items to be obtained from ancillary units, and items to be purchased from the market or from specialized manufacturers will be the same as in chapter 6.

The subcontracting relationship of large- to small-scale units, and the relationship of small-scale units to ancillary units is shown in figure 10 below. The small-scale units and the ancillary units under this plan can be located in a town.

⁵ These specialized units also work for industries other than the bicycle industry.

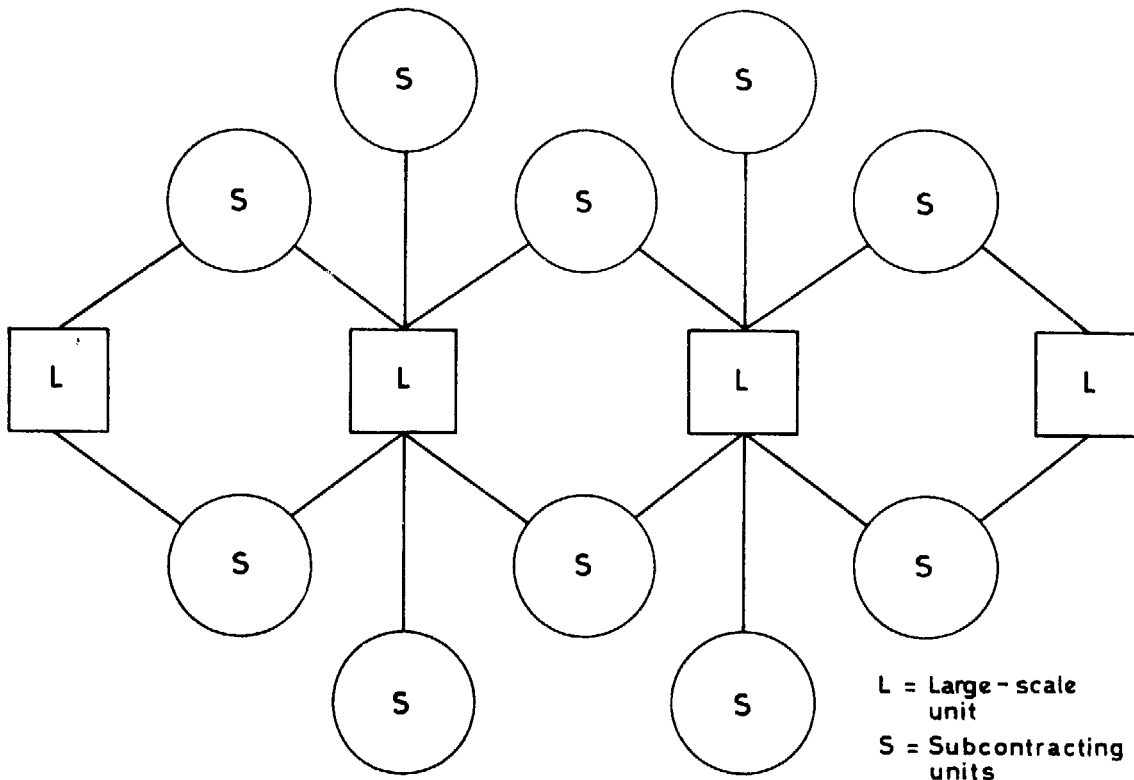


Figure 10. Diagram of relationship of small-scale units to ancillary units

Plan C. Setting up a functional industrial estate for bicycle manufacturers

The annual output of each central assembly unit, the items to be manufactured in the central unit and those to be obtained from ancillary units will be the same as in Plan B except for the following:

The central assembly units and ancillary units will be in the same industrial estate;

Independent process-oriented units for electroplating, enamelling, heat treatment and so on can be set up as specialized units;

All parts must be sold by the ancillary units to the central assembly units as a primary obligation;

The pricing of parts made by ancillary units is calculated by cost-study allowing for a fixed percentage profit.

In this type of estate, the industry can be actively assisted by the government in several ways:

Setting up design and prototype development centres;

Providing a tool room for common service to manufacture dies, jigs, fixtures and so on;

Providing a testing laboratory for quality control;

Establishing raw material depots;

Providing institutional agencies for financial and marketing help;

Constructing the sheds in functional industrial estates.

Figure 11 gives a plan of a functional industrial estate for making bicycles.

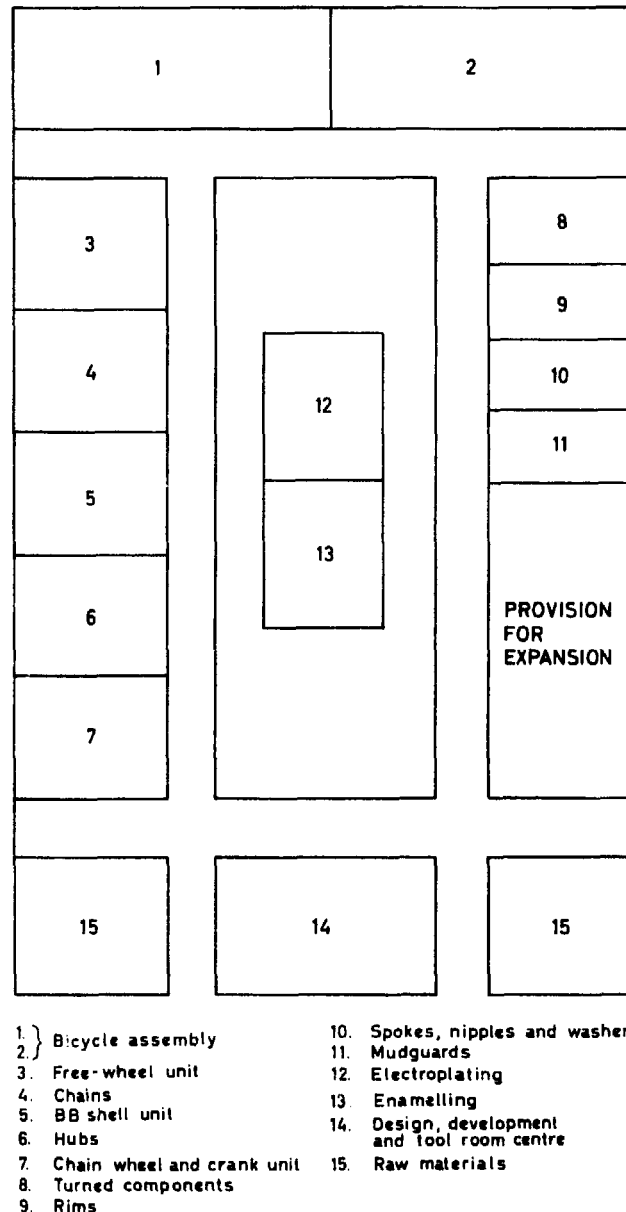


Figure 11. Layout of a functional industrial estate for the manufacture of bicycles

STANDARD SPECIFICATIONS, QUALITY CONTROL AND INSPECTION FOR HOME AND EXPORT

STANDARD SPECIFICATIONS

In the bicycle industry the manufacture of components in accordance with standard specification is desirable to achieve interchangeability of parts and components. In the early stages of bicycle manufacturing in India, some large-scale units manufactured parts and components in accordance with their own company standards, and some units used British Standard Specifications. The industry soon felt the need to establish national standards of quality in the manufacture of parts and components as well as interchangeability. The Indian Standards Institution therefore took up the work of establishing standards.

Standard specifications formulated by the Indian Standards Institution

The Indian Standards Institution has published 22 standards for the various parts and components of the bicycle including the glossary of terms used in the bicycle industry. A list of the standards is given in table 19 at the end of this chapter. These standards include almost all the important parts in which interchangeability is desirable. Thus the industry has been encouraged to manufacture components of quality standards.

The Indian Standards Institution is in the process of revising some existing standards and formulating new ones. Draft standards have been prepared for saddles, bicycle cotter pins, washers and nuts. The Indian bicycle standards being revised at the time of writing include: rim tapes and buckles; cranks and chain wheel; free-wheel and chains; bottom bracket assembly; components (axle, adjustable cup, fixed cup and locking nut). The following will be standardized: mudguards; sports cycles; and method of sampling for bicycle components.

The Indian Standards Institution has established a mark scheme, awarding the ISI mark for items that are manufactured to ISI specifications. Manufacturers may approach the Indian Standards Institution if they have the necessary equipment to manufacture components according to the Institution's specifications. After inspection and approval, the ISI mark may be stamped by manufacturers on their products. This mark gives assurance to the consumer that the product has been manufactured in accordance with quality standards. The Indian Standards Institution charges a nominal fee to manufacturers for the use of its mark. Institution officers visit the manufacturing units periodically to satisfy themselves that the products are being manufactured according to their standards. Some manufacturers of bicycle components have the ISI mark on their products.

QUALITY CONTROL

The extent of quality control exercised by the manufacturing units depends upon the raw materials, the type of machinery and equipment, the skill of the labour and the specification followed. In addition to the specifications for the end product, specifications have been prescribed for the raw materials that go into its manufacture. The type of plant and machinery used by both the large- and small-scale units is such that by and large there is no difficulty in making parts to standard. Manufacturers of parts and components, therefore, have introduced quality control at all stages of manufacture and testing is done at all stages to maintain it. The Central Small Industries Organisation has been playing a significant role in giving technical assistance enabling the adoption of quality control methods at all stages of manufacture in small-scale units. Material testing facilities have been provided at various places for this purpose.

INSPECTION FOR THE HOME MARKET

There is no compulsory inspection prescribed for the bicycle in the home market. But, where purchases are made by the Director General of Supplies and Disposals for government departments, inspection is carried out in accordance with the Indian Standards Specifications. Where standards are not available, the inspection wing of this department has its own standards. It is not essential for a manufacturer to have the ISI mark on his goods but the items should meet the standards set by the Director General of Supplies and Disposals.

In some states, such as Punjab where the manufacture of bicycles and bicycle components is concentrated, the state Government has introduced a quality marking system by which a "Q" mark is given to commodities made in accordance with the standards prescribed by the state Government. The facility is given to several small-scale units and the products of these units are found more acceptable to consumers since they bear an assurance of quality. Also for quality marking, the national standards prescribed by the Indian Standards Institution are being introduced wherever possible.

INSPECTION FOR EXPORT

At present there is no compulsory inspection for bicycles or parts that are exported. Manufacturers are aware of this, but they do produce quality goods in accordance with the standard specifications. The need for quality control and inspection before export has, however, been realized by the Government of India and steps have been taken to implement such a scheme. Under this scheme components and bicycles will be inspected in accordance with the specifications of the ISI or another agency prescribed by the Government. Inspection will be carried out by the Export Inspection Agencies at Cochin, Madras, Calcutta, Bombay and Delhi, which will be authorized to give certificates before export. Manufacturers will be required to exercise quality control at all stages during the manufacture of their product.

Even though there is no compulsory inspection before export, the bicycles and parts that are exported from India have, by and large, been widely accepted, and the increase of exports is an indication that their quality is satisfactory. However, the scheme of inspection before export will benefit the industry and give confidence to the consumers abroad. Compulsory inspection before export will make the bicycle industry more quality conscious.

Table 19

INDIAN STANDARD SPECIFICATIONS FOR BICYCLES AND PARTS

<i>ISI Specification numbers</i>	<i>Title of specification</i>
IS 532:1964	Bicycle tube valves
IS 623:1963	Bicycle frames
IS 624:1961	Bicycle rims
IS 625:1963	Bicycle handle-bars
IS 626:1963	Bicycle seat pillars
IS 627:1961	Bicycle chains
IS 628:1963	Bicycle pedal assembly
IS 629:1963	Bicycle hub assemblies
IS 630:1961	Bicycle spokes and nipples for spokes
IS 960:1958	Bicycle rim tapes and buckles
IS 1131	Bicycle bottom bracket assembly components
IS 1132	
IS 1133	
IS 1134	
IS 1281:1958	Bicycle cranks and chain wheels
IS 1282:1958	Bicycle cotter pins, washers and nuts
IS 1283:1958	Bicycle free-wheels
IS 2039:1964	Steel tubes for bicycle and allied purposes
IS 2061:1962	Bicycle front forks
IS 2415:1963	Bicycle rubber tubes
IS 2484:1964	Dimensions of steel tubes for bicycle purposes
IS 2898:1965	Chromium alloy steel balls
IS 2973:1964	Bicycle steering head assembly
IS 3404:1966	Ladies' bicycle frames
IS 3798:1966	Glossary of terms used in the bicycle industry

EXPORT

The bicycle industry of India has made a significant contribution to the country's export of light engineering products. India is now exporting bicycles and bicycle parts to several countries in Africa, the Far East, the Middle East, the United Kingdom and the United States. The industry faces competition from countries such as the Federal Republic of Germany, Japan and the United Kingdom, but the quality of its exports and its competitive position have enabled it to enter the world market.

Export performance

The export of bicycles started in 1956—1957 when the value of exports by the industry was Rs. 0.21 million, but there has been a gradual increase since then. In 1966—1967 the figure rose to Rs. 13.33 million. During this period the export of bicycle parts also grew substantially. Parts such as chains, spokes, saddles, free-wheels, rims, steel balls, tires and tubes are the major items of export. A graph indicating the export of bicycles and bicycle parts from 1956 to 1967 is given in figure 12. The industry aims at an export target of Rs. 50 million by the end of 1970—1971.

Foreign market

Indian bicycles and parts find a good market in Afghanistan, Hong Kong, Indonesia, Iran, Iraq, Kenya, Malawi, Mozambique, Nigeria, Peru, the Sudan, Syria, Thailand, Uganda, the United Republic of Tanzania, the United States and Zambia. In the Middle East countries, the most popular Indian bicycle is the roadster model—single bar and double bar. This model is the most popular in developing countries because it is strongly built and can be used in places where roads are poor. Countries such as the United States, however, prefer sports models. To cater to this preference, India has manufactured sports models with the special features required by these countries. Recently, Indian bicycles have even been exported to the United Kingdom from whom India imported almost all its bicycles only a decade ago.

Channels of export

The Engineering Export Promotion Council gives assistance and guidance to bicycle exporters through its regional offices in India and in other countries. Bicycles are exported through established export houses, and merchant exporters, and by manufacturers directly. The merchant exporters handle mainly the

export business of small-scale manufacturers. In some places, state-owned small industries corporations also export for small-scale industries. The Central Small Industries Organisation gives special assistance to small industrialists to enter the export market. The Cycle Manufacturers' Association of India has created a cycle export pool to assist its members in finding export markets.

Export aid for small-scale industries (EASI Scheme)

To give special assistance to small-scale units, the Government of India started the EASI Scheme. This scheme, which is operated through the State Trading Corporation of India, boosts the export of commodities including bicycles and bicycle parts.

Under the scheme, the Small Industries Service Institutes locate a few competent manufacturers for the particular item on the basis of capacity, quality and quantity of production; price, finish and packaging of the product; and business reputation and keenness to export. If a product is thought to be suitable for export, a small team of officers representing the scheme visits the factory and selects the production. If the packaging is not appropriate, the scheme arranges for a new design and printing of top class packaging and presentation material.

Essentially the scheme brings together manufacturers and foreign buyers because the small-scale manufacturer is not normally in a position to locate a buyer and negotiate export business. Under the scheme, a manufacturer receives all the assistance needed to become a competent exporter; the Small Industries Service Institutes give free technical assistance to fill the gap. The small-scale manufacturer also receives assistance to import raw materials and machinery for his industry. Cash assistance is available to the manufacturer who exports the products.

Competitive position in the world market

According to information available to the authors, the countries that offer keen competition to India on the world market are: China (mainland), the Federal Republic of Germany, France, Japan, the United Kingdom and Yugoslavia. Because of the large number of models they manufacture, Japan and European countries have the advantage over India in such markets as the United States. Yugoslavia offers strong competition, particularly in Indonesia, and the competition from China (mainland) is mostly in the Middle East. In order to meet competition from these countries, India has taken steps to introduce new models.

Another factor that influences the competitive position of Indian bicycles is price. As raw materials are the biggest factor in determining the cost of a bicycle, a country having the raw materials at competitive prices is at an advantage. Efforts are being made to make raw materials available to the bicycle industry of India at international prices. This effort should help to improve India's competitive position on the world market.

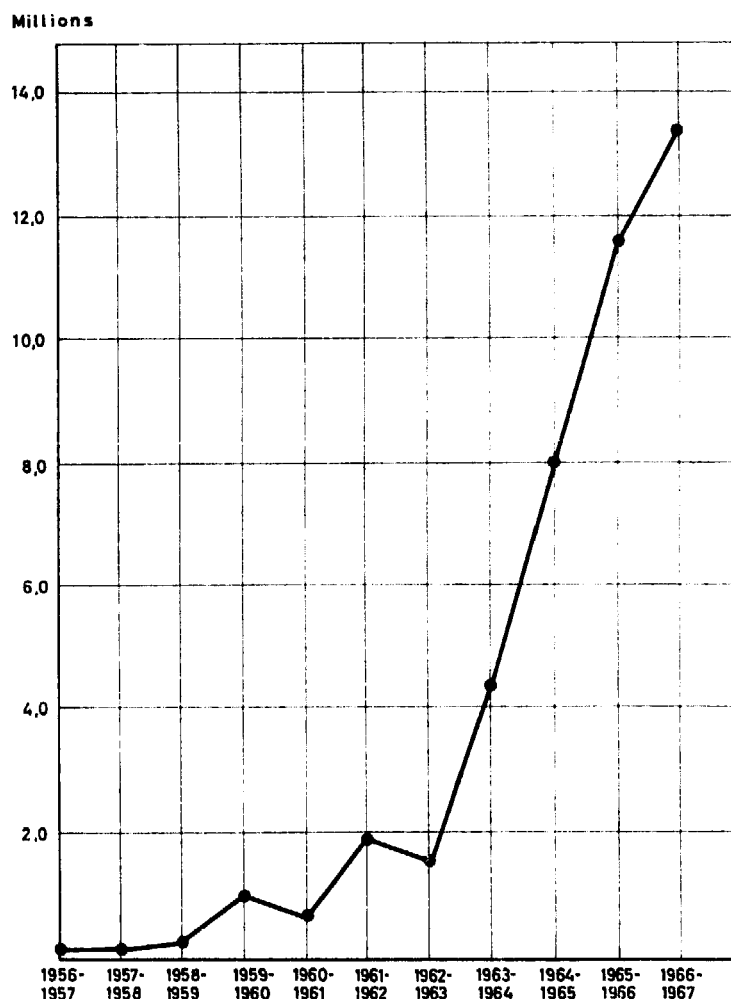


Figure 12. Export of bicycles and parts—India, 1956 to 1967

Prospects

The various measures undertaken and continuous improvement in the quality of Indian bicycles will help to increase the export volume in the near future. Bicycle manufacturers in India have also made collaboration agreements with entrepreneurs of other countries and manufacturing units have been established in countries such as Ceylon. An increasing demand is being received to set up similar units in developing countries in Africa. This will further help the export of bicycle parts.

The bicycle industry, therefore, promises to be a substantial foreign exchange earner in the future.

COMPARISON OF PRODUCTIVITY IN THE LARGE- AND SMALL-SCALE SECTORS

The most efficient size for an industry depends on the nature of the industry. The basic industries such as iron and steel are predominantly large, but the consumer industries, for example those producing bicycles, sewing machines or electric fans, may be either large- or small-scale.

Determination of optimum size of units

It is difficult to determine the optimum or most efficient size for manufacturing units on the basis of theory. Optimum size can at best be determined by the measurement of cost and the technical or other benefits to be derived from various possible sizes. Factors that commonly influence optimum size are: technology, finance, managerial talent, market, and other external reasons.

Technical innovations play an important role. For each stage of technology there is an optimum size in terms of equipment and production. This factor has been largely responsible for achieving efficiency and productivity in the small-scale bicycle industry in India.

Concept of productivity

Productivity in an industry has a comprehensive meaning that includes the optimum use of available resources and the elimination of all forms of waste. Productivity is a function of the cost price of a commodity as determined by the sum of the cost of each resource put into the production of that commodity. Productivity is measured as the ratio of achievement in the form of output of goods to the effort put in, in terms of real resources. Profitability, however, is not the measure of productivity.

The important resources from a productive point of view are men, material, machines and management. The accent on productivity varies from country to country. In industrially developed countries where human resources are costly and scarce, the accent is on mechanization and automation. In developing countries, on the other hand, there is no shortage of manpower for industry but rather a shortage of materials and equipment. The emphasis in such countries should be on economic application of scarce materials and fuller use of available machinery. In these countries, the techniques of production should not be the same as those in advanced countries but should be selected and adapted to suit the local social, economic and technological environment.

Productivity in the bicycle industry in India

The factors mentioned above have influenced the bicycle industry in India, both in the large- and small-scale sectors. Even where large-scale bicycle manufacturers have collaborated with foreign firms, their plants are not identical to those of their counterparts abroad; instead they have been adapted to make use of available resources, particularly manpower. In the small-scale sector there is a higher proportion of manpower employed and simple machines with technical innovations used.

COMPARISON OF LEVELS OF PRODUCTIVITY IN THE LARGE- AND SMALL-SCALE SECTORS

In comparing levels of productivity, the main difficulty arises in selecting a standard of measurement. The suitability of any standard of measurement depends upon the significance of "efficiency", which may differ according to its context. It may be measured as labour productivity if output per worker is the unit of measurement. If, however, efficiency means "securing greatest results at least cost", the cost of production per unit of output becomes the standard of measurement. In a wider sense efficiency may mean employment opportunities and raising the standard of living for the workers, lower prices for consumers and greater returns to investors. As these objectives are often in conflict, it is difficult to evolve a common standard of efficiency.

In the analysis of productivity in comparing the large- and small-scale sectors of the bicycle industry, the coefficients of measurement used are:

- Cost of production per unit of output
- Output per worker
- Investment per worker

Comparison of cost of production per unit of output

The manufacturing processes and techniques of production in the large- and small-scale sectors have been discussed in chapter 4. According to current methods of production in both sectors, bicycle manufacturing has been divided into the following groups of parts and components to compare the relative cost of production:

- (a) Frames, forks, chain stays, seat stays, pressed parts, handle-bars;
- (b) Mudguards, hubs, chain wheel and cranks, turned components, BB shells, rims;
- (c) Chains, spokes and nipples.

(a) *Frames, forks, chain stays, seat stays, pressed parts, handle-bars.* The main factors influencing cost of production in the manufacture of parts under this group are men and materials. The comparison of levels of productivity indicates that the cost of production of parts in this group will be almost the same in both sectors. Large-scale units use costlier materials but less manpower; small-scale units use more manpower and cheaper, easily available raw materials.

For example, for the manufacture of fork blades, tapered ERW tubes are used by large-scale units. In the small-scale sector, the raw material used is MS sheets from which tubes are made by the unit itself. In this process the small-scale unit uses cheaper, easily available raw material but employs more manpower. By virtue of their scale of production this can be done only in the small-scale sector. Management costs are lower in small-scale units compared to large-scale ones. The small-scale units benefit by this saving and by using cheaper materials. Large-scale units benefit by lower costs of labour and their larger scale of production.

(b) *Mudguards, hubs, chain wheel and cranks, turned components, BB shells, rims.* The main factors influencing cost of production in the manufacture of parts under this group are machines and materials. The costs of production of components in this group are more for small-scale units than for large-scale ones because manpower does not play as significant a role as in group A. The scale of production and types of machine influence the cost of production. Large-scale units have the advantage of sophisticated machines; small-scale units use semi-automatic or single-operation machines. To some extent, the disadvantage of the small-scale units is compensated by cheaper materials and technical innovations as shown in the example of rim manufacture. However, if it is economic, small-scale ancillary units are set up to use the same types of machine as large-scale units. Production costs in such units are lower as a result of smaller overhead.

(c) *Chains, spokes and nipples.* The main factors influencing the cost of production in this group are machines, materials and management costs (overhead). The machines and materials used by both sectors are identical. However, production costs are lower in small-scale units compared to large-scale units because of lower overhead.

A typical analysis of the elements in the cost structure of a bicycle is set out below in table 20.

Table 20

ELEMENTS IN THE COST STRUCTURE OF A BICYCLE

<i>Element of cost</i>	<i>Per cent of total cost</i>
Raw materials and finished parts including tires and tubes	59.4
Labour and establishment	8.3
Other direct charges	14.8
Depreciation and overhead	3.8
Return on capital	6.4
Excise duty	7.3
TOTAL	100.0

This analysis indicates that in a bicycle the cost of raw materials is by far the highest cost element. As it is necessary to use only the proper raw materials, waste in all forms should be avoided. Attention should be given to increasing

the productivity of labour. Such measures should ultimately reduce the unit cost of production, particularly in small-scale units where high productivity will bring more benefit.

Comparison of capital investment and output per worker

A typical analysis of the capital investment and output per worker in the bicycle industry is given below in table 21.

Table 21

ANALYSIS OF THE CAPITAL INVESTMENT AND OUTPUT PER WORKER

<i>Firm</i>	<i>Total capital investment (Rupees)</i>	<i>No. of workers employed</i>	<i>Investment per worker (Rupees)</i>	<i>Output per worker (Rupees)</i>
<i>Large-scale</i>				
Firm A	19,625,000	1,042	18,834	17,066
Firm B	1,302,000	349	3,730	10,522
<i>Small-scale</i>				
Firm C	104,000	54	1,922	4,431
Firm D	45,000	16	1,156	3,106

The above table indicates that output per worker is related to investment per worker. Higher investment per worker results in higher output. In countries where high output per worker is the primary objective, the small- and large-scale sectors must use the same type of plant and equipment to achieve equal production. In this case, however, the sub-contractors should be tied by direct ancillary relationships with the assembly units for consumption of their output.

SUGGESTIONS FOR IMPROVEMENT OF PRODUCTIVITY IN SMALL-SCALE UNITS

The following measures are suggested to improve productivity in the small-scale units:

1. Educate entrepreneur-managers to plan and organize various aspects of management making use of scientific and technical equipment and adopting modern management practices.
2. Train workers to increase their productivity.
3. Train entrepreneur-managers in the essentials of financial management such as cost and budget control.
4. Use raw materials to best advantage.
5. Reduce rejections by proper methods of quality control.
6. Use of work study to achieve optimum use of resources.
7. Adoption of proper production planning and control.
8. Fuller utilization of machinery and equipment.

COST OF MANUFACTURING A COMPLETE BICYCLE

Bicycle manufacturing costs may be non-recurring or recurring.

NON-RECURRING COSTS

Non-recurring, or capital, costs include the costs of land, buildings, machinery and equipment, office equipment and transport. Because land and building costs differ widely from place to place, for the purpose of this paper the costs used for land and buildings are the average costs prevailing in industrial towns and medium-sized cities in India. The average cost of land used is Rs. 1.00 to Rs. 1.50 per ft²; the average cost of construction is Rs. 15.00 to Rs. 20.00 per ft².

The cost of machinery and equipment also vary depending upon the type, quality and capacity. The cost assumed here is for machinery of good quality and suitable to the scale of production.

The cost of office equipment and conveyances depend upon the size of the manufacturing unit, the number of staff and transport needs.

RECURRING COSTS

Recurring, or operating, costs include the costs of raw materials and components, labour and overhead.

Raw materials and components

The cost of basic raw materials varies little within a country. The cost of components, however, may vary slightly depending upon the location of the ancillary unit manufacturing the components. In the bicycle industry the cost of raw materials and components form a substantial part of the total cost; therefore the extent to which waste is controlled and the kind of process used both influence manufacturing costs. Certain processes require comparatively costly raw material; for others cheaper raw material may serve the purpose. The factors governing the choice of material are the scale of production and type of machines used.

Table 22

NON-RECURRING AND RECURRING COSTS FOR PRODUCTION OF
25,000 BICYCLES, 1966: SCHEME 1 (MEDIUM-SIZED CITY)

	<i>Unit costs (Rupees)</i>	<i>Total costs (Rupees)</i>
<i>Non-recurring costs</i>		
(a) Land 36,000 ft ² at Rs. 1.50 per ft ²		54,000
(b) Building	<i>area (ft²)</i>	
Manufacturing shop	4,000	
Brazing and welding section	2,500	
Enamelling section	2,500	
Electroplating section	3,000	
Machine shop	1,500	
Stores	3,000	
Office space	1,500	
	Total 18,000	
Total cost of construction at Rs. 20 per ft ²		360,000
(c) Machinery and equipment (as listed in chapter 6, table 17)		413,800
Manufacturing and processing shops	367,300	
Machine shop ^a	46,500	
(d) Office equipment and conveyance		73,200
TOTAL NON-RECURRING COST		901,000
<i>Recurring costs per month</i>		
(a) Labour		14,300
Salary for one works engineer	1,000	
Salary for one foreman	600	
Salary for three supervisors	1,200	
Salary for fifteen skilled workers (tool and die makers, machine operators, electroplaters, enam- ellers, painters, etc.) at Rs. 250 per month	3,750	
Salary for thirty semi-skilled workers at Rs. 175 per month	5,250	
Salary for twenty unskilled workers at Rs. 125 per month	2,500	
(b) Raw materials and components		229,250
Cost of raw materials for the items under manu- facturing programme as given in chapter 6 at Rs. 35 per bicycle including consumable stores, chemicals, etc.	73,000	
Cost of components and parts to be purchased from ancillary units and market as given in chapter 6 at Rs. 75 per bicycle	156,250	

Table 22 (continued)

	Unit costs (Rupees)	Total costs (Rupees)
(c) <i>Overhead</i>		31,600
Salary for one managing director	1,200	
Salary for one office manager	600	
Salary for two sales officers	800	
Salary for one accountant	400	
Salary for two clerk-storekeepers.....	500	
Salary for one stenographer	250	
Salary for three peons and watchmen	450	
Electricity.....	750	
Water	150	
Interest on working capital at 9 per cent per year..	6,000	
Depreciation on fixed assets		
Building at 5 per cent per year	1,500	
Machinery and equipment at 10 per cent per year	4,000	
Maintenance of plant and machinery	1,000	
Labour welfare	1,000	
Miscellaneous office expenses	3,000	
Marketing, advertising.....	4,000	
Packing and forwarding	6,000	
TOTAL RECURRING COSTS PER MONTH		275,150
<i>Working capital for three months</i>		
<i>Labour</i>	42,900	
<i>Raw materials</i>	690,000	
<i>Overhead</i> (except interest and depreciation)	60,300	
TOTAL WORKING CAPITAL FOR THREE MONTHS		793,200
<i>Total recurring manufacturing costs per year</i>		
<i>Labour</i>	171,600	
<i>Raw materials</i>	2,760,000	
<i>Overhead</i>	379,200	
<i>Manufacturing cost (recurring) per bicycle</i> approximately .	132	

^a Machine shop has been substituted for tool room and heat treatment shop since it has been suggested that the latter be located as a common service facility centre in a functional industrial estate.

Labour

The cost of labour may vary considerably in different parts of a country. The scale of production and the type of machines used influence labour costs. For example, if a power press is used, the labour cost per unit of production will be less than for the same job done on a hand press. However, whether to use a power press or hand press depends upon the quantity of work and the prevailing wage rates.

Overhead

The recurring costs in this category are salaries of staff, electricity, water, interest on working capital, depreciation on fixed assets, maintenance of plant and machinery, labour welfare, miscellaneous office expenses, marketing and advertising, packing and forwarding. Overhead charges vary considerably depending upon the type and organization of the unit, its size and capital costs. The location of a unit influences the amount of money spent for electricity, water, marketing, advertising, salaries of staff, etc.

In the following two schemes given below in tables 22 and 23, the cost of manufacturing complete bicycles at different levels of production have been detailed. Both schemes are suitable for the small-scale sector.

In working out the schemes, the following factors have been taken into consideration:

- (a) The units will manufacture all parts and components given in chapter 6, and will buy from ancillary units or the market the other components and parts mentioned in chapter 6;
- (b) The production capacity under scheme 1 will be 25,000 bicycles per year; under scheme 2, 15,000 bicycles per year;
- (c) The lower scale of production envisages the use of cheap labour and simple machines with technical innovations. In both schemes the cost of raw materials and purchased components is the same;
- (d) Scheme 1 will be run by a private limited company; Scheme 2 will be operated as a proprietary concern.

Table 23

NON-RECURRING AND RECURRING COSTS FOR PRODUCTION OF
15,000 BICYCLES, 1966: SCHEME 2 (SMALL-SIZED TOWN)

	Unit costs (Rupees)	Total costs (Rupees)
<i>Non-recurring costs</i>		
(a) Land 24,000 ft ² at Rs. 1.00 per ft ²		24,000
(b) Building	area (ft ²)	
Manufacturing shop	2,500	
Brazing and welding	1,500	
Enamelling section	1,500	
Electroplating section	2,000	
Machine shop	1,500	
Stores	2,000	
Office space	1,000	
	Total 12,000	
Total cost of construction at Rs. 15 per ft ²		180,000
(c) Machinery and equipment (as listed in chapter 6, table 18)		263,150
(d) Office equipment and conveyance		50,000
TOTAL NON-RECURRING COST		517,150

Table 23 (continued)

	Unit costs (Rupees)	Total costs (Rupees)
<i>Recurring cost per month</i>		
(a) <i>Labour</i>		12,200
Salary for one foreman	750	
Salary for 3 supervisors	1,200	
Salary for ten skilled workers at Rs. 250 per month	2,500	
Salary for thirty semi-skilled workers at Rs. 175 per month	5,250	
Salary for twenty unskilled workers at Rs. 125 per month	2,500	
(b) <i>Raw materials and components</i>		137,500
Cost of raw materials for items under manufacturing programme as given in chapter 6 at Rs. 35 per bicycle	43,750	
Cost of components and parts to be purchased from ancillary units and market as given in chapter 6 at Rs. 75 per bicycle	93,750	
(c) <i>Overhead</i>		23,750
Salary for one manager (proprietor)	1,000	
Salary for one office manager	500	
Salary for two sales officers	800	
Salary for one accountant	400	
Salary for one clerk-storekeeper	250	
Salary for one typist	200	
Salary for three peons and watchmen	450	
Electricity	500	
Water	150	
Interest on working capital at 9 per cent per year	3,750	
Depreciation on fixed assets		
Building at 5 per cent per year	750	
Machinery and equipment at 10 per cent per year	2,500	
Maintenance of plant and machinery	750	
Labour welfare	750	
Miscellaneous office expenses	3,000	
Marketing, advertising	4,000	
Packing and forwarding	4,000	
TOTAL RECURRING COSTS PER MONTH		173,450
<i>Working capital for three months</i>		
<i>Labour</i>	36,600	
<i>Raw materials</i>	412,500	
<i>Overhead</i> (except interest and depreciation)	47,250	
Total recurring manufacturing cost per year		1,985,400
<i>Labour</i>	146,400	
<i>Raw materials</i>	1,650,000	
<i>Overhead</i>	189,000	
<i>Manufacturing cost (recurring) per bicycle: approximately</i>	133	

MARKETING AND DISTRIBUTION

The bicycle has proved to be, beyond doubt, an essential vehicle in both urban and rural areas, particularly for people of low and middle income groups. It is highly desirable, therefore, that bicycles be well distributed wherever they are needed. To achieve this type of distribution, sales organizations must be well-knit throughout a country.

Distribution pattern followed by the large-scale sector

The pattern of distribution followed in the large- and small-scale sectors of India is not the same. Most of the large-scale units have regional offices in a few towns. These centres are at Delhi, Ludhiana, Bombay, Calcutta and Madras. Through the regional offices bicycles are supplied to authorized dealers in each state who either sell the bicycles directly or supply to sub-dealers or retailers. Most of the sales to consumers are through retail shops selling several brands of bicycles. Sales are made by dealers, sub-dealers and retailers on a commission basis. The distribution of bicycle parts, components and accessories that are manufactured by the large-scale units follow almost the same pattern.

Distribution followed by the small-scale sector

The pattern of distribution in the small-scale sector is not uniform. Some small-scale units appoint agents on a regional basis who, in turn, through dealers and retailers, book orders for bicycles. Manufacturers fill these orders directly to the dealers and retailers. Booking of orders by regional agents and sales through dealers and retailers is also on a commission basis. The output of some small-scale units does not warrant regional agents. These units have their own sales representatives who book orders with dealers and retailers. They may also have their own retail shop at the factory.

Future prospects of marketing and distribution

The Indian bicycle industry has not yet faced any problem of marketing because the demand for bicycles has been met by the supply. This may not continue, however, and industrialists should therefore study the basic functions of marketing and distribution. A programme of instruction in distribution, marketing and management appears to be needed now for successful operation in the future. Instruction is needed at all levels—for retailers, wholesalers, and manufacturers—and should include training in scientific storage, transportation and financial management. Realizing this need for instruction, the Central

Small Industries Organisation, through the network of small industries service institutes in each state, has organized short and long courses in management in which "distribution education" is an important subject.

As the bicycle market becomes more consumer oriented, sales can be increased through instalment buying; improvement in the quality of the product; new designs and models; exhibitions of small-scale industry products; and marketing through state small industries corporations with permanent displays of bicycles and parts in their showrooms.

CONCLUSIONS AND RECOMMENDATIONS

The contribution of small-scale industries to the production of bicycles as discussed in this report leads to the following conclusions:

1. Among light engineering commodities, the bicycle is one of the best suited for production in both the small- and large-scale sectors.
2. In the large-scale sector sophisticated and automatic plants make the industry capital-intensive. In the small-scale sector more manpower and comparatively simple machines are used.
3. Bicycle components are highly suited for production in economically viable subcontracting units.
4. Complete bicycles can be manufactured by units making only a few parts themselves and obtaining the rest from co-operating small-scale units.
5. The manufacture of bicycles is technically and economically feasible in a functional industrial estate.
6. A bicycle industry can be started with the manufacture of only a few simple parts and components and the rest imported.
7. Basic raw materials can be imported initially until these materials are produced within the country to replace the imported ones.
8. The bicycle is a suitable commodity to earn foreign exchange through export. New models and designs should be introduced frequently to meet the requirements of foreign markets.
9. Standardization of parts and quality control during manufacture are needed to ensure interchangeability and product quality.
10. Basic technical skills in sheet-metal working, tool making, electroplating, enamelling and heat treatment are needed to start the industry.
11. A high level of productivity should be assured through optimum use of raw materials and proper training of workers.
12. Financial assistance in the form of hire-purchase of machinery and liberal credit will accelerate the growth of the industry.

Recommendations

The following recommendations are based on the Indian experience:

1. Bicycle manufacturing can be started in developing countries on the basis of phased production. Initially the industry can import specialized items and manufacture simple ones. Gradually imports are reduced with a view to reaching self-sufficiency. Under a three-phase programme, the imports would be phased as follows:
 - Phase 1. Free-wheels, BB shells, hubs, rims, chains, spokes and nipples, tires and tubes, steel balls;
 - Phase 2. Free-wheels, BB shells, hubs, tires and tubes, steel balls;
 - Phase 3. Tires and tubes, steel balls, BB shells.
2. Suitable tariff protection should be ensured where necessary to get the industry started.
3. Subcontracting units should be utilized wherever possible for the manufacture of components to develop specialization.
4. Functional programmes, preferably on industrial estates, should be set up to manufacture bicycles.
5. Basic raw materials should be imported by the government if necessary. Later these raw materials should be produced, if possible, by the country itself to help make the industry self-sufficient.
6. In planning the development of the bicycle industry, consideration should be given to reserving capacity in both the large- and small-scale sectors. This would evidently be necessary if the product were to be manufactured in both sectors.
7. The government should help the growth of the industry by:
 - (a) Providing designs and developing bicycle prototypes;
 - (b) Training workers in basic skills;
 - (c) Training entrepreneur-managers for industrial management, financial management and market management;
 - (d) Providing common facility centres such as tool rooms and testing laboratories;
 - (e) Providing technical expertise to plan and guide the industry on technical matters;
 - (f) Providing raw material depots;
 - (g) Supplying machinery on a hire-purchase basis;
 - (h) Importing components for distribution to the manufacturers initially;
 - (i) Constructing functional industrial estates.

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