

“Gauges and Standards  
as affecting Shop and Manufactory Administration.”<sup>1</sup>

By HERBERT J. MARSHALL.

IN dealing with so wide and far-reaching a subject, the Author purposes giving a brief outline of the result which he has personally observed from the use of gauges and standards as a means for improving the quality and for cheapening the cost of work produced. The methods described are in no way regarded as satisfying or final, but only as first steps to the introduction of systematic methods of manufacture into an old established factory. This is necessarily a work of time, and also of considerable labour; yet the results to be obtained will, it is believed, amply compensate for the time expended. The frequently recurring words “detail” and “unit” are used to designate an elementary part, the production of which is considered without reference to its relation to any other part.

*Manufacturing in Detail.*—In order to produce work cheaply and accurately, it is absolutely necessary to consider the production of every individual unit, entirely without reference to any other part with which it must fit. In producing large quantities of some simple article of general use, this is an easy matter; but in covering a large range of manufacture, a beginning must be made by standardization of detail, *i.e.*, parts approximately similar must be tabulated throughout all the articles to be manufactured. Parts must be put through in quantities, as opposed to the old practice of putting work through in sets, *i.e.*, in groups of parts which go together to form a whole; by the new method only is it possible to obtain the fullest advantage from the use of gauges and standards.

*The Old Way.*—The object of putting work through in sets or groups of parts was twofold:—(1) To ensure all parts fitting each other correctly; (2) to ensure units being put through in correct numbers for forming complete sets.

*The New Way.*—Under the plan now to be described, these requirements are met as follows:—(1) Limit or other gauges are employed to give accuracy of fit and to ensure interchangeability. (2) To ensure stocking complete sets, a system of storage is introduced, which gives for each unit a maximum number to be stocked; and the several numbers are so fixed as to keep the parts stocked in correct proportion.

---

<sup>1</sup> *The Engineer*, vol. xcv. p. 628. *Engineering*, vol. lxxv. pp. 824 and 836.

*General Results of the use of Gauges and Standards.*—The use of gauges and standards is absolutely essential to the new plan, in order to secure the following results :—

(i.) Uniformity and accuracy of workmanship, which are necessary for interchangeability.

(ii.) The cheapening of production by employing special machines for individual operations.

(iii.) The cheapening of production resulting from the application of routine methods to the production and storage of individual parts or details.

(i.) *Uniformity and Accuracy of Workmanship* may be considered under two subdivisions :—

(i.a) The limiting of travel of cutting-tools, by the use of stops or micrometer adjustments in a lathe or other tool, or by fixed points on templates or gauges in planing-, slotting-, or milling-machines, in order to give without measurement the diameter of work or the position of a plane surface, which has to correspond with the diameter or plane surface of other work produced in quantities on other tools. This enables the manufacturer to produce separately, and yet with accuracy, articles, say, with flanges which have to couple together, or plane surfaces which have to come together at fixed distances from certain points.

(i.b) The use of limit-gauges for ensuring the correct fit of any two units which come together in the formation of a fitted article. By the use of limit-gauges, details or units can be produced in special tools separately and correctly, without reference to any other part. It is generally advisable to have one fixed limit for holes; and for parts fitting into the holes to vary the limit, so as to suit the fit required. The limits allowed will also vary so as to suit the requirements of different manufacturers. For work approximately up to 6 inches diameter, the following limits have been found by the Author to give satisfactory results as far as they have been used; but as yet they have been tried only in certain sections of work :—

For holes . . . . .	- 0·0005 go in, + 0·001 not go in
Force fits . . . . .	+ 0·006 go on, + 0·004 not go on
Driving fits . . . . .	+ 0·0015 „ + 0·0005 „ „
Sliding fits . . . . .	- 0·0005 „ - 0·0015 „ „
Running fits . . . . .	- 0·0015 „ - 0·0025 „ „
Loose fits . . . . .	- 0·004 „ - 0·006 „ „

(ii.) *Employment of Special Machines for Individual Operations* may likewise be considered under two subdivisions :—

(ii.a) *Standardization of operation.*—Where individual parts or details cannot be assimilated, it is advisable to consider single similar operations on a number of different parts. For instance, a flange-facing operation may be performed as a first operation by a specially designed tool, preparatory to dealing with more complicated operations on the same part by more suitable tools; or threaded spindles of all sorts may be produced by (1) rough turning, and (2) grinding, preparatory to (3) threading by a special tool.

(ii.b) *Standardization of detail* is the most important point for consideration in manufacture, and cannot be thoroughly carried out except with the help of gauges. Standardization throughout manufacture facilitates close attention to the best and cheapest way of carrying every operation through: in castings, from the best form of pattern for meeting the requirements of the foundry to the best form of casting for the application of special tools in each operation. No single operation in which time can be saved is too trivial for the fullest consideration as to specialization in methods and machinery; the time so expended must be looked upon as first cost for effecting a daily saving. Such consideration will include the time occupied in setting, in which there is often as much margin for saving as in the time taken in actual cutting. Standards facilitate the use of special chucks and fixtures, in which a casting or forging is readily set by locating-points, and quickly clamped by eccentric clamps, knurled, headed screws, or by other similar means. Drilling too on circular or rectangular surfaces should, where possible, be standardized; and drill-jigs should be used as a means for accurate reproduction.

(iii.) *Routine Production and Storage of Individual Parts or Details.*—A method of storage is adopted, wherein each individual part or detail has a symbol for type, and a number for size; and a maximum and minimum for stock are fixed. A stock-card is kept in a slide in each compartment in the stores, and on it are entered all incomings and outgoing. When the minimum is reached, an order is issued for a fresh supply. In this way the stock of every part is automatically kept up to its right level.

An illustration of the actual working of the routine method is furnished by the manufacture of a spring governor as carried out in practice. If the governor were to be taken as a starting-point for introducing the system into a factory, all similar parts used in any other work throughout the factory would be tabulated with it. For instance, all screws throughout the factory would be tabulated, being divided first into types, and then into sizes of

each type. The type would be designated by a symbol, and the size by a number; any screw would be referred to on drawings by symbol and number, and produced as, say, screw "A 1," quite irrespective of what its use may be. The standard would be fixed, and would be used by the drawing-office in all future designs, as far as ever possible. In the same way spindles would be classified as:—plain spindles, plain spindles with collar-heads, plain threaded spindles, etc. Pins, and all iron and brass, and all other parts throughout the factory, would be treated in the same way.

*Figs. 1 to 6* in the Appendix will give a general idea of how the manufacture is carried out.

*Fig. 1.* Stock Card. Form "T.S." on one side; Form "T.O." on the other. All standard details are stocked in properly labelled compartments in the stores.

*Fig. 2.* Order form, issued to proper department when minimum of stock is reached.

*Fig. 3.* Urge order, issued as soon as stock falls within a certain approach to what is fixed as danger limit.

*Fig. 4.* Report card, to be brought under notice of management, should order not be filled when danger limit is reached. The management is thus enabled to discover the weak points in production which require consideration.

*Figs. 5.* Operation-cards, giving operations performed in producing each part or detail. The cards here shown are the result of actual tests made in the tool-room, and are stored at the tool producing the parts, in a special rack provided for the purpose. The reference-letters on the cards are only for the purposes of this Paper. When issuing an order to the tools, the correct equipment of cutting-tools, which is referred to in the tool-stores by a card-index, is issued along with the maximum number of castings. Cutting-tools are returned with finished work, and are corrected before storing to be ready for re-issue. When standardization of cutting-tools is completed, they will be referred to on operation-cards by symbols.

*Fig. 6.* Table of spring governor under consideration, giving reference-letter for each part or detail, with number of parts required by fitter for each size of governor, and indicating where such parts may be found in the stores. The shelves in the stores are grouped in series, each series having a letter, and each tier a number. Where a part or detail is to be used also elsewhere in manufacture, a symbol is added. When the part is a special part used for this governor only, the size of governor replaces the symbol. The Table is referred to for issue of a full set of parts to

the fitter. The fitted governors themselves are ruled by maximum and minimum stock, in the same way as the tooled parts. The valve-seats produced to limit-gauge are pressed into the bodies by a special press in the stores, and the bodies are issued to the fitter with a full set of details or parts; if the set is not complete, nothing is issued until it is so.

The manufacture of the spring governor has been selected as a brief and simple exemplification of the results of using gauges and standards in a workshop. But before the system here laid down can be successfully carried out, it is absolutely necessary to begin by—(1) standardization of parts or details; (2) standardization and subdivision of tooling-operations; (3) standardization of limits of error, for enabling parts or details to be produced separately; (4) standardization and specialization of machine-tools and their equipment. In order to carry out 2, 3, and 4, a properly equipped tool-room is indispensable.

The points here touched upon are so closely connected with the use of gauges and standards, and so entirely dependent thereon, that it is hardly possible even briefly to approach the subject for discussion without mentioning them.

The following speakers took part in the discussion of the subject:—Captain Sankey, Messrs. W. H. Allen, T. Matthews, and W. J. Crossley, Lt.-Col. Crompton, Messrs. M. Robinson and H. Davey, Professor Barr, Messrs. T. Parker, A. Sharpe, C. A. Parsons, H. Campbell, and Whitfield.

## APPENDIX.

77311-1-03

*Figs. 1.*

**Form T.S.** Name of Part, *Governor Body.* Symbol, *2 inches.*

When Minimum Stock of *24* is reached, Order *48.*

Enter on Form "T.O."

Weight of *1 = 24½ lbs.*

Order to *Lathe No. 238. Turret Department.* Send Details with Order.

Urge to *Turret Department* when Stock is at 0.

Report to Manager when Stock is at 0; and when Order was Received from Fitted Stores.

SHOP AND MANUFACTORY ADMINISTRATION.

81

Date.	In.	Out.	Stock.	Date.	In.	Out.	Stock.	Date.	In.	Out.	Stock.	Date.	In.	Out.	Stock.
15/9/02	..	..	56												
30/10/02	..	12	44												
4/12/02	..	12	32												
10/12/02	..	12	20												
20/1/03	..	12	8												
21/1/03	48	..	56												
3/2/03	..	12	44												
7/4/03	..	12	32												

[THE INST. G.E. SUPP.]

g

*Figs. 1 (continued)*

Form "T.O."

Name of Part, Governor Body.

Maximum Stock 48.

Minimum Stock 24.

When ordering fill in

Line I. Date of Ordering.

Line II. Stock at Date of Ordering.

Line III. Order Reference No.

Line IV. Date when Order is Filled.

The Order must be returned with Parts.

No excess received, and all work paid for on Order Tickets only.

I. Date of Ordering . .	10/12/02								
II. In Stock . . . .	20								
III. Order No. . . .	26 T.								
IV. Date when Filled .	21/1/03								

NOTE WHEN RE-ORDERING.

Fig. 2.

.....190 Order No. ....

**DEPT.**

TOOL No.

*Please Supply*

SYMBOL No. Price  
 REC<sup>d</sup>. IN STORES .....190

*N.B.—This Card must be returned with work when finished. Piecework will be paid on these Cards only.*

65952/5/01. *Storekeeper.*

Fig. 3.

.....190 Order No. ....

To .....  
 71768/4/02.

Please urge Order for

sent to you on .....

*Storekeeper.*

Fig. 4.

.....190 Order No. ....

To .....  
 71768/4/02.

Please Report below why Order for

sent to you on .....

and urged on .....

is not yet filled.

*Storekeeper.*



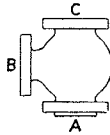
*Figs. 5.*

Reference Letter *A.*

TOOL, Multiple Drill.

ARTICLE, Governor Body.

SYMBOL, 1½ Inch to 4 Inches.



78787-1-03

OPERATION.	CHUCKING.....I.	EQUIPMENT.
1	Mount casting in special box- template.	Special box-template.
2	Drill flange A.	4 drills in holders, in spindles.
3	Turn template over, and drill flange B.	"    "    "    "    "
4		
5		
6		
7		

CHUCKING.....II.

1	Drop special flange-template on C.	Special flange-template.
2	Drill flange C.	4 drills in holders, in spindles.
3		
4		
5		
6		
7		

AUTOMATIC TAPPING MACHINE.

CHUCKING.....III.

1	Cramp casting on table.	
2	Tap flange C.	1 tap in holder, in spindle.
3		
4		
5		
6		
7		

CHUCKING.....IV.

1	Fix casting on special angle- plate.	Special angle-plate.
2	Tap flange B.	1 tap in holder, in spindle.
3		
4		
5		
6		
7		

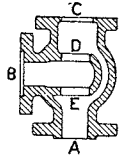
Reference Letter A.

Figs. 5 (continued).

TOOL, 1 1/4-Inch Turret Lathe, with Auxiliary Cross-Slide Turret.

ARTICLE, Governor Body.

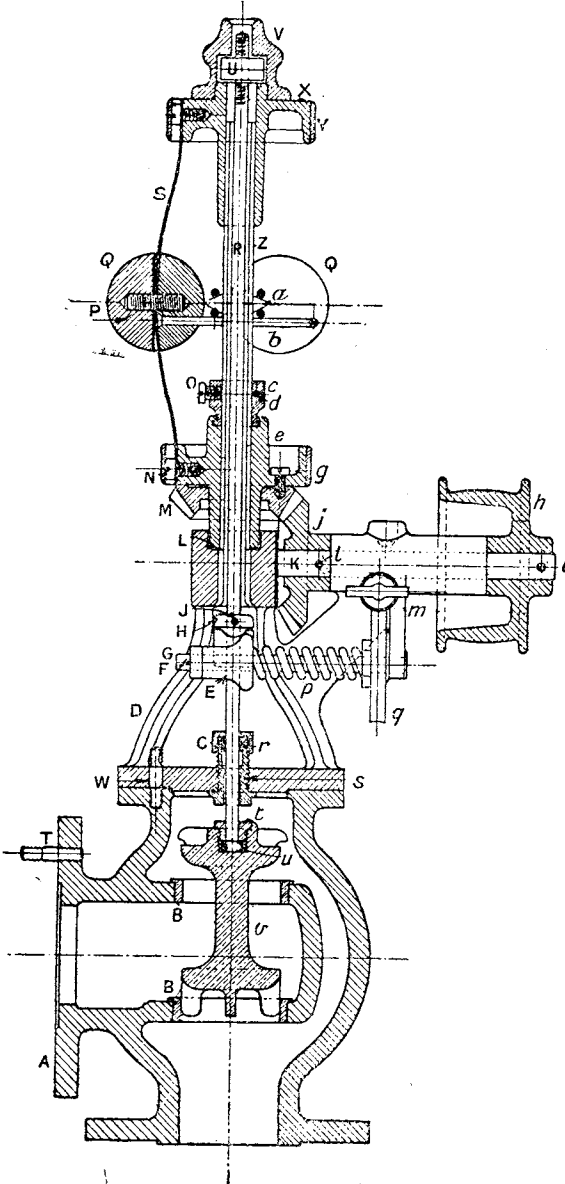
SYMBOL, 1 1/2 Inch to 4 Inches.



78787-4-03

OPERATION.		CHUCKING.....I.	EQUIPMENT.
1	Mount casting in special face-plate chuck.		Special face-plate chuck.
2	Turn top and face flange C.		1 roughing and 1 finishing tool in auxiliary turret, worked to stops and micrometer on cross slide.
3	Bore C, D, and E.		1 boring bar with 3 roughing cutters, and 1 boring bar with 3 finishing cutters, and 2 reamers fixed in turret worked to stops. (2 limit gauges)
4	Face D and E for shoulders of valve seat.		1 turning tool in auxiliary turret, worked to stops.
5			
6			
7			
CHUCKING.....II.			
1	Mount casting on special angle-plate.		Special angle-plate.
2	Turn top and face flange B.		1 roughing and 1 finishing tool in auxiliary turret, worked to stops and micrometer on cross slide.
3	Recess flange B.		1 turning tool in auxiliary turret, worked to stops and micrometer on cross slide.
4			
5			
6			
7			
CHUCKING.....III.			
1	Mount casting on angle and centering plate fixed on face-plate.		Special angle and centering plate.
2	Turn top, form nipple, and face flange A.		1 roughing and 1 finishing tool in auxiliary turret, worked to stops and micrometer on cross slide.
3			
4			
5			
6			
7			

Fig. 6.



SPRING GOVERNOR

Name of Part.

- Body . . . . .
- Valve Seats . . . . .
- Stuffing-Box Nut . . . . .
- Bracket . . . . .
- Adjusting-Lever Fork . . . . .
- Split Pin . . . . .
- Adjusting Spindle . . . . .
- Lifting Collar . . . . .
- Taper Pins . . . . .
- Lay Spindle . . . . .
- Steel Washers . . . . .
- Bevel Wheel . . . . .
- Set Screws . . . . .
- Ball Studs . . . . .
- Balls . . . . .
- Valve Spindle . . . . .
- Ball Flat Springs . . . . .
- Body Studs . . . . .
- Valve-Spindle Nuts . . . . .
- Cap . . . . .
- Body Studs . . . . .
- Top Slide . . . . .
- Rings for Top and Bottom Slides . . . . .
- Vertical Spindle . . . . .
- Washer for Separating Balls . . . . .
- Ball Check-Wires . . . . .
- Stop Collar . . . . .
- Taper Pin . . . . .
- Bottom Slide . . . . .
- Set Screw . . . . .
- Pulley . . . . .
- Bevel Wheel . . . . .
- Taper Pins . . . . .
- Worm Spindle . . . . .
- Spiral Spring . . . . .
- Worm Wheel . . . . .
- Gland . . . . .
- Stuffing-Box . . . . .
- Chased Gland . . . . .
- Valve-Spindle Button . . . . .
- Valve . . . . .

Reference Letter.	No. in a Set.	Where Stored.									
		1½ Inch.		2 Inches.		2½ Inches.		3 Inches.		4 Inches.	
		Symbol.	Shelf.	Symbol.	Shelf.	Symbol.	Shelf.	Symbol.	Shelf.	Symbol.	Shelf.
A	1	1½ in.	D.3	2 in.	D.3	2½ in.	D.3	3 in.	D.3	4 in.	D.3
B	2	A.9 & 10	B.3	A.15 & 16	B.3	A.19 & 23	B.3	A.23 & 24	B.3	A.28 & 29	B.3
C	1	E.7	B.12	E.7	B.12	E.7	B.12	E.7	B.12	E.7	B.12
D	1	1½ in.	D.3	2 in.	D.3	2½ in.	D.3	3 in.	D.3	4 in.	D.3
E	1	1½ in.	D.3	2 in.	D.3	2½ in.	D.3	3 in.	D.3	4 in.	D.3
F	1	No. 1	V.1	No. 2	V.1	No. 3	V.1	No. 4	V.1	No. 5	V.1
G	1	M.D.1	G.1	M.D.1	G.1	M.D.2	G.1	M.D.3	G.1	M.D.4	G.1
H	1	1½ in.	B.3	2 in.	B.3	2½ in.	B.3	3 in.	B.3	4 in.	B.3
J	2	3D.3	R.3	3D.3	R.3	3D.3	R.3	3D.3	R.3	3D.3	R.3
K	1	M.E.1	G.1	M.E.1	G.1	M.E.2	G.1	M.F.1	G.1	M.F.2	G.1
L	6	A.0	U.1	A.1	U.1	A.2	U.1	A.3	U.1	A.4	U.1
M	1	1½ in.	D.1	2 in.	D.1	2½ in.	D.1	3 in.	D.1	4 in.	D.1
N	2	C.X.1	O.2	C.X.1	O.2	C.X.1	O.2	C.X.13	O.2	C.X.13	O.2
O	1	C.X.1	O.2	C.X.1	O.2	C.X.1	O.2	C.X.1	O.2	C.X.1	O.2
P	3	C.D.D.11	O.2	C.D.D.11	O.2	C.D.D.11	O.2	C.D.D.11	O.2	C.D.D.23	O.2
Q	3	1½ in.	D.1	2 in.	D.1	2½ in.	D.1	3 in.	D.1	4 in.	D.1
R	1	A.1	B.3	A.3	B.3	A.5	B.3	A.9	B.3	A.11	B.3
S	15 below 3 in.; 12 for 3 in. and 4 in. 4 up to 4 in.; 6 for 4 in.	No. 1	V.1	No. 2	V.1	No. 3	V.1	No. 4	V.1	No. 5	V.1
T		D.58	U.3	D.B.47	U.3	D.B.47	U.3	D.98	U.1	D.B.50	U.3
U	2	1½ in.	D.1	2 in.	D.1	2½ in.	D.1	3 in.	D.1	4 in.	D.1
V	1	1½ in.	D.1	2 in.	D.1	2½ in.	D.1	3 in.	D.1	4 in.	D.1
W	4	D.58	U.1	D.58	U.3	D.58	U.1	D.B.50	U.3	D.B.50	U.3
X	1	1½ in.	D.1	2 in.	D.1	2½ in.	D.1	3 in.	D.1	4 in.	D.1
Y	2	No. 1	V.1	No. 2	V.1	No. 3	V.1	No. 4	V.1	No. 5	V.1
Z	1	M.C.1	G.1	M.C.2	G.1	M.C.3	G.1	M.C.4	G.1	M.C.5	G.1
a	1	1½ in.	D.3	2 in.	D.3	2½ in.	D.3	3 in.	D.3	4 in.	D.3
b	3	No. 1	V.1	No. 2	V.1	No. 3	V.1	No. 4	V.1	No. 5	V.1
c	1	1½ in.	D.1	2 in.	D.1	2½ in.	D.1	3 in.	D.1	4 in.	D.1
d	1	..	..	..	..	..	..	3D.3	R.3	3D.3	R.3
e	1	1½ in.	D.1	2 in.	D.1	2½ in.	D.1	3 in.	D.1	4 in.	D.1
g	1	C.R.1	O.2	C.R.1	O.2	C.R.1	O.2	C.X.2	O.2	C.X.2	O.2
h	1	1½ in.	K.13	2 in.	K.13	2½ in.	K.13	3 in.	K.13	4 in.	K.13
j	1	1½ in.	D.1	2 in.	D.1	2½ in.	D.1	3 in.	D.1	4 in.	D.1
l	2	3D.3	R.3	3D.3	R.3	3B.3	R.3	3B.6	R.3	3B.6	R.3
m	1	1½ in.	B.3	2 in.	B.3	2½ in.	B.3	3 in.	B.3	4 in.	B.3
p	1	No. 1	V.1	No. 2	V.1	No. 3	V.1	No. 4	V.1	No. 5	V.1
q	1	1½ in.	B.3	2 in.	B.3	2½ in.	B.3	3 in.	B.3	4 in.	B.3
r	1	Z.A.1	A.5	Z.A.1	A.5	Z.A.1	A.5	Z.A.2	A.5	Z.A.2	A.5
s	1	D.1	B.14	D.1	B.14	D.1	B.14	D.2	B.14	D.2	B.14
t	1	A.4	B.7	A.4	B.7	A.4	B.7	A.6	B.7	A.6	B.7
u	1	Z.O.1	A.5	Z.O.1	A.5	Z.O.1	A.5	Z.O.2	A.5	Z.O.2	A.5
v	1	C.1	B.16	C.2	B.16	C.3	B.16	D.1	B.16	D.2	B.16