PROGRESS REPORT NO. 4

May 11, 1929

UNIVERSITY OF WISCONSIN - MILWAUKEE

AN INVESTIGATION OF REST PAUSES, WORKING CONDITIONS, AND INDUSTRIAL EFFICIENCY

SUPPLEMENTARY PROGRESS REPORT AS OF May 11, 1929

WESTERN ELECTRIC COMPANY

EXPLANATORY PREFACE

Previous progress reports of these studies have been issued. The last such report gave all of the data and results obtained up to August 15, 1928. The present report is a supplement. The following pages do not repeat data presented in the earlier report except where such data have been revised or where it seems more natural to include complete instead of partial graphs and tables. Instead of preparing this supplementary report in the form of separate sections to be inserted in the previous report, it has seemed wiser to prepare it as a unit, with references to the earlier report. This report, therefore, reflects earlier results and when read by itself it will give an outline picture of what has been accomplished to date. From the following index the reader may see at a glance the outline of the report and by means of the page numbers he may turn readily to any data of special interest. The numbering and naming of tables is such that any tables included in previous reports have the same numbers and titles as previously, while similar tables for new tests are named and numbered similarly under the sections relating to those tests. Graphs are numbered in accordance with the page which they follow in this report.

INDEX

AN INVESTIGATION OF REST PAUSES, WORKING CONDITIONS, AND INDUSTRIAL EFFICIENCY

SUPPLEMENTARY PROGRESS REPORT

WESTERN ELECTRIC COMPANY

SECTION I

OBJECT OF THE STUDY

Studies made in the past regarding the improvement of working conditions, the establishment of piece rates, and reduction in the cost of manufacture, have shown large variation in output over different periods of the day and between different working groups. The answers to such questions as the following are of great import to industry and to the industrial worker:

1. Why does output drop in the afternoon?
2. Do operators actually get tired out?
3. Are rest pauses desirable?
4. How important are changes in working equipment?
5. What is the attitude of the operators?
6. What are the effects of a shorter working day on output?

It was decided to conduct certain tests in order to determine the answers to such questions; and in order to investigate these conditions it was proposed to select and segregate certain groups of operators for study.

The first test undertaken, the one with which this report is chiefly concerned, was begun on April 25, 1927, to determine what effect rest pauses and various hours of work would have in increasing the efficiency of an operator. As the test developed, factors other than the rest pauses were found to be of outstanding importance and the study naturally broadened into a consideration of the various conditions which effect output, speed, efficiency, health, and contentment. Many additional questions have arisen relating to such problems as basis of pay, overtime, the five day week, the measurement of fatigue, and the relation between supervision and output.

It may be recalled from previous progress reports that the first relay assemblers group has been through a series of periods of experiment. During the first period, known as the base period, the operators continued with their large gang under the accustomed conditions while their production data was taken to serve as a basis for comparison with production in the test room. The second period duplicated the first except for the fact that the operators were removed from the large room occupied by the main gang and placed in the test room. This gave basis for judging the effect of change in environment alone. The first major variation was introduced in the third period. The operators segregated for test were formed into a new gang and placed upon a gang piece rate independent of the main gang. In the fourth period two five minute rest pauses were introduced, one in the morning, and one in the afternoon. In the fifth period, the length of these rest pauses was increased to ten minutes. The sixth period introduced six five minute rest pauses, three in the morning, and three in the afternoon. In the seventh period a morning lunch furnished by the Company was introduced. A rest pause of fifteen minutes was provided for this and in addition a pause of ten minutes was inserted in the afternoon. The eighth* and ninth periods duplicated the seventh except that the working day was ended at half past four and four o'clock in the afternoon respectively. The tenth period reverted to a duplication of the seventh period.

Since the writing of these former progress reports, there have been three additional periods. In the eleventh period a five day week was tried. During this period the morning lunch and afternoon rest pause were continued as in the four preceding periods. While the operators did not work on Saturday morning, they were paid their hourly rate for this time which gave them approximately one-half of their Saturday morning earnings on the gang piece work basis. The twelfth period reverted to a duplication of the third period, that is, a return to the regular factory working hours without morning lunch or rest pauses. The thirteenth period, which still is in effect, is a duplication of the seventh period except that the operators furnish their own lunches while the Company furnishes a beverage.

On the following page is a listing of these periods by number by which they may be identified throughout the remainder of the report; the dates included and the duration of each period, and the times of day rest pauses were inserted are shown.

*At the beginning of this period operators Nos. 1 and 2 were replaced. These new operators had no base period of observation. Their performance in subsequent periods is compared with period No. 8 as a base.

SCHEDULE OF TEST PERIODS
FIRST RELAY ASSEMBLY GROUP

Period Number	Period Name	Dates Included	Duration	Beginning of Rest Pauses A.M.	P.M.
		1927			
1	In Regular Dept.	4-25 to 5-10	Appr. 2 wks.		None
2	Introduction to Test Room	5-10 " 6-11	5 wks.		None
3	Special Gang Rate	6-13 " 8- 6	8 "		None
4	Two 5 Min. Rests	8- 8 " 9-10	5 "	10:00	2:00
5	Two 10 Min.Rests	9-12 " 10- 8	4 "	10:00	2:00
6	Six 5 Min. Rests	10-10 " 11- 5	4 "	8:45, 10:00 11:20	2:00, 3:15, 4:20
7	15 Min. A.M. Lunch 10 Min. P.M. Rest			9:30	2:30
		1928			
8	Same as No. 7, but 4:30 Stop	1-23 to 3-10	7 wks.	9:30	2:30
9	Same as No. 7, but 4:00 Stop	3-12 " 4- 7	4 "	9:30	2:30
10	Same as No. 7, (Check)	4- 9 " 6-30	12 "	9:30	2:30
11	Same as No. 7, but Sat. A.M. off	7- 2 " 9- 1	9 "	9:30	2:30
12	Same as No. 3, (No Lunch or Rests)	9- 3 " 11-24	12 "		None
		1929			
13	Same as No. 7, but operators furnish own lunch. Company furnishes beverage.	9- 3 to present		9:30	2:30

SECTION II

FINDINGS
FIRST RELAY ASSEMBLY GROUP

A. OUTPUT

1. Basic Data

As indicated in previous reports all output data have been converted to figures indicating what the output would have been in assembling a specific type of relay; namely, E-901. These conversions were based upon the time and difficulty of assembling each relay. The daily output for each operator* and the average for the group as a whole are reported in the "Basic Data Table" which follows.

This table shows (a) the daily output in terms of perfect E-901 relays which would have been produced during the working time indicated; (b) the output for Wednesday and Friday (repair work days) which would have been produced had no repair work been necessary; (c) the output that would have been attained if Saturday were a full day; and (d) the output which would have been produced on holidays and days absent if the operator had maintained her average rate for the days worked that week.**

The different figures referred to above were computed as follows:

(a) The equivalent daily output is expressed in terms of the number of perfect E-901 relays assembled. When the full day is broken because of a conference, a hospital visit, or some other interference, the daily output is

*The numbering of the operators is as follows:

No.	Periods 1 to 7 Inclusive	Period 8 to Present Time
1		
2		
3		
4		ak
5		
6	(Layout Operator) I	" "

**Figures described under (b) and (c) are used only in comparing the output of different days of the week. Figures described under (d) are used in studying comparative weekly outputs.

figured by dividing the actual output converted to the common type (E-901) basis by the time worked* in assembling relays. The quotient (hourly output) is multiplied by the number of hours left in the working day after time for repairs, rest pauses, and early closing has been deducted from the length of the normal working day (8-3/4 hours).

(b) The daily output which would have been produced if no time had been taken for repairs is figured the same as the above except that the time for repairs is not deducted from the number of working hours in the day in obtaining the figure to multiply by the hourly rate.

(c) The output that would be attained if Saturday were a full working day is figured by dividing the Saturday output on the basis of E-901 relays by the number of hours worked* and multiplying this figure by the number of hours in the full working day of the period in question.

(d) The output for holidays and days absent is figured by dividing the weekly output by the number of hours worked* and multiplying this figure by the number of hours that would have been worked on the day in question.

*Personal time out is not deducted in computing "time worked."

BASIC DATA TABLE FOR FIRST RELAY ASSEMBLY GROUP

DAILY OUTPUT IN TERMS OF E-901 RELAYS

The right hand columns under each operator's number show the output of perfect E-901 relays which would have been produced during the working time indicated at the left. (All defective relays were repaired on the operator's time.)

The left hand columns show what the operator would have produced on Wednesdays and Fridays if she had used no time for repairs; figures in parentheses for Saturdays give the results for a full day. These figures are not used in any totals. They are for comparing outputs for the days of the week.

Figures in quotations are for holidays or absences.

Date	Hr. & Min. Worked		Operators 1		2		3		4		5		Av. for Group	
PERIOD NO. 1 - BASE PERIOD IN REGULAR DEPARTMENT														
4-25-27	"8:45"		"447"		"448"		"441"		"442"		"426"		"441"	
4-26	8:45		463		461		442		440		430		447	
4-27	8:45		468		452		442		415		434		442	
4-28	8:45		439		469		439		450		435		446	
4-29	8:45		434		435		427		411		416		425	
4-30	4:15	(417)	203	(406)	198	(473)	230	(362)	176	(374)	182	(406)	198	
Total	48:00		2454		2463		2421		2334		2323		2399	
5- 2-27	8:45		446		413		443		441		447		438	
5- 3	8:45		452		441		423		435		418		434	
5- 4	8:45		452		441		440		452		451		447	
5- 5	8:45		444		421		433		421		408		425	
5- 6	8:45		424		400		441		427		433		425	
5- 7	4:15	(430)	209	(385)	187	(453)	220	(434)	211	(404)	196	(421)	205	
Total	48:00		2427		2303		2400		2387		2353		2374	
5- 9	8:45		419		441		457		421		420		432	
*5-10 A.M.	5:30		250		240		259		283		258		258	
Period	104:45		5300		5207		5278		5122		5096		5205	
Av.Hr.Output			50.5		49.7		50.4		49.0		48.6		49.7	

* Not included in period but is in week.

PERIOD NO. 2 - INTRODUCTION TO TEST ROOM														
*5-10 P.M.	3:15		165		154		154		165		138		155	
5-11-27	8:45		414		412		427		468		400		424	
5-12	8:45		414		449		456		485		423		445	
5-13	8:45		402		393		427		480		464		433	
5-14	4:15	(453)	220	(424)	206	(475)	231	(488)	237	(416)	202	(451)	219	
Total	48:00		2284		2295		2411		2539		2305		2366	
4 days of test room			1450		1460		1541		1670		1489		1521	
5-16-27	8:45		441		473		450		475		478		463	
5-17	8:45		455		466		465		490		480		471	
5-18	8:45		459		477		473		492		442		469	
5-19	8:45		445		482		461		457		429		455	
5-20	8:45		425		494		466		459		409		451	
5-21	4:15	(381)	185	(461)	224	(435)	211	(457)	221	(410)	199	(412)	200	
Total	48:00		2410		2616		2526		2595		2440		2518	

Date	Hr. & Min. Worked	1	2	3	4	5	Av. for Group
5-23-27	"8:45"	"389"	"453"	"429"	"436"	"428"	"427"
5-24	8:45	447	417	438	450	437	438
5-25	8:45	416	424	459	437	424	427
5-26	8:45	400	417	447	446	424	427
5-27	8:45	431	409	420	450	392	420
5-28	4:15	(397) 193	(364) 177	(432) 210	(455) 221	(410) 199	(412) 200
Total	48:00	2276	2297	2403	2440	2304	2344
5-30-27	8:45	409	410	385	421	418	409
5-31	8:45	382	423	342	418	412	395
6- 1	8:45	426	402	347	403	426	401
6- 2	8:45	413	416	349	435	423	407
6- 3	8:45	426	404	451	407	402	418
6- 4	4:15	(387) 188	(402) 195	(473) 230	(461) 224	(432) 210	(431) 209
Total	48:00	2244	2250	2104	2308	2291	2239
6- 6-27	8:45	420	416	438	426	424	425
6- 7	8:45	410	439	446	449	426	434
6- 8	8:45	415	426	443	432	453	434
6- 9	8:45	404	437	450	439	465	439
6- 10	8:45	426	419	450	446	443	437
6- 11	4:15	(393) 191	(428) 208	(451) 219	(422) 205	(398) 193	(418) 203
Total	48:00	2266	2345	2446	2397	2404	2372
Period	222:30	10646	10968	11020	11410	10928	10994
Av.Hr.Output		47.8	49.2	49.5	51.3	49.1	49.4

* Not included in period but is in week.

PERIOD NO. 3 - SPECIAL GANG RATE

6-13-27	8:45	429	434	456	439	433	438
6-14	8:45	426	421	459	436	439	436
6-15	8:45	430	465	460	435	441	446
6-16	8:45	407	446	443	429	449	435
6-17	8:45	401	389	441	442	447	424
6-18	4:15	(376) 183	(395) 192	(449) 218	(451) 219	(430) 209	(420) 204
Total	48:00	2276	2347	2477	2400	2418	2383
6-20-27	8:45	375	397	442	439	466	424
6-21	8:45	412	456	480	450	470	454
6-22	8:45	410	392	438	442	450	426
6-23	8:45	410	421	469	444	455	440
6-24	8:45	412	427	478	455	431	441
6-25	4:15	(424) 206	(441) 214	(455) 221	(445) 216	(436) 212	(440) 214
Total	48:00	2225	2307	2528	2446	2484	2399
6-27-27	8:45	415	398	415	Vacation	472	425
6-28	8:45	401	438	468	"	466	443
6-29	8:45	398	403	460	"	450	428
6-30	8:45	374	409	468	"	432	421
7- 1	8:45	370	396	467	"	386	405
7- 2	4:15	(356) 173	(399) 194	(500) 243	"	(412) 200	(417) 202
Total	48:00	2131	2238	2521		2406	2324

Date	Hr. & Min. Worked		1		2		3		4		5		Av. for Group
7- 4-27	"8:45"		"426"		"430"		"475"		"448"		"426"		"441"
7- 5	8:45		400		397		473		425		426		424
7- 6	8:45		458		464		495		449		426		458
7- 7	8:45		428		433		477		461		443		448
7- 8	8:45		425		464		460		444		413		441
7- 9	4:15	(422)	205	(379)	184	(475)	231	(471)	229	(416)	202	(433)	210
Total	48:00		2342		2372		2611		2456		2336		2422
7-11-27	8:45		418		473		465		461		467		457
7-12	8:45		410		457		453		468		474		452
7-13	8:45	386	363	417	406	483	477	477	469	456	428	444	429
7-14	8:45		430		470		482		484		460		465
7-15	8:45	457	430	458	445	507	499	478	471	464	455	473	460
7-16	4:15	(474)	230	(424)	206	(494)	240	(474)	230	(445)	216	(462)	224
Total	48:00		2281		2457		2616		2583		2500		2487
7-18-27	8:45		412		416		481		465		451		445
7-19	8:45		423		475		456		487		461		460
7-20	8:45	458	450	459	444	486	479	475	467	435	415	463	451
7-21	8:45		445		496		481		469		437		466
7-22	8:45	445	439	453	452	472	467	485	480	459	448	463	457
7-23	4:15	(500)	243	(474)	230	(510)	248	(496)	241	(424)	206	(481)	234
Total	48:00		2412		2513		2612		2609		2418		2513
7-25-27	8:45		466		488		478		498		428		472
7-26	8:45		491		499		496		479		470		487
7-27	8:45	476	466	495	478	489	472	461	433	467	448	478	459
7-28	8:45		450		463		463		446		443		455
7-29	8:45	430	430	414	408	477	463	458	458	460	447	448	441
7-30	4:15	(410)	199	(461)	224	(484)	235	(459)	223	(426)	207	(448)	218
Total	48:00		2502		2560		2607		2537		2443		2530
8- 1-27	8:45		431		474		438		447		458		450
8- 2	8:45		412		454		478		458		447		450
8- 3	8:45	481	464	470	455	506	480	471	464	455	439	477	460
8- 4	8:45		439		471		480		457		443		458
8- 5	8:45	460	444	471	455	489	478	468	458	419	409	461	449
8- 6	4:15	(437)	212	(464)	225	(484)	235	(470)	228	(410)	199	(453)	220
Total	48:00		2402		2534		2589		2512		2395		2487
Period	384:00		18571		19328		20561		17543*		19400		19545
Av.Hr.Output			48.4		50.3		53.5		52.2		50.5		51.0

* 336 hours not 384 hours

PERIOD NO. 4 - TWO 5-MINUTE RESTS

8- 6-27	8:35		459	Vacation		424		460		425		442
8- 9	8:35		450	"		468		445		426		447
8-10	8:35	450	435	"	473	465	439	431	445	428	452	440
8-11	8:35		454	"		465		464		457		460
8-12	8:35	449	441	"	439	436	456	452	456	442	450	443
8-13	4:10	(474)	230	"	(495)	240	(445)	216	(435)	211	(462)	224
Total	47:05		2469			2498		2468		2389		2456

Date	Hr. & Min. Worked	1		2		3		4		5		Av. for Group	
					Operators								
8-15-27	8:35		451		442		485		438		462		456
8-16	8:35		457		461		480		447		437		456
8-17	8:35	455	437	426	416	486	481	461	451	431	415	452	440
8-18	8:35		453		388		474		477		441		447
8-19	8:35	449	445	415	403	455	455	480	478	436	420	447	440
8-20	4:10	(430)	209	(395)	192	(459)	223	(447)	217	(410)	199	(428)	208
Total	47:05		2452		2302		2598		2508		2374		2447
8-22-27	8:35		445		471	Vacation			470		430		454
8-23	8:35		452		444	"			494		418		452
8-24	8:35	366	336	412	381	"		486	447	458	441	431	401
8-25	8:35		450		434	"			457		437		445
8-26	8:35	447	444	435	435	"		469	469	436	428	447	444
8-27	4:10	(455)	221	(445)	216	"		(474)	230	(398)	193	(443)	215
Total	47:05		2348		2381				2567		2347		2411
8-29-27	8:35		437		472		435		445		442		446
8-30	8:35		440		509		456		439		453		459
8-31	8:35	436	432	497	494	444	397	444	441	432	426	451	438
9- 1	8:35		448		486		480		459		451		465
9- 2	8:35	423	413	475	469	454	443	473	466	446	436	454	445
9- 3	4:10	(441)	214	(488)	"237"	(430)	209	(432)	210	(453)	220	(449)	218
Total	47:05		2384		2667		2420		2460		2428		2471
9- 5-27	"8:35"		"444"		"443"		"469"		"471"	Vacation			"457"
9- 6	8:35		453		434		464		455	"			452
9- 7	8:35	436	423	444	438	466	453	471	466	"		454	445
9- 8	8:35		446		440		470		480	"			459
9- 9	8:35	454	448	463	460	490	487	492	492	"		475	472
9-10	4:10	(459)	223	(449)	218	(495)	240	(461)	224	"		(466)	226
Total	47:05		2437		2433		2583		2588				2511
Period	235:25		12090		9783*		10099*		12591		9538*		12296
Av.Hr.Output			51.4		51.9		53.5		53.5		50.6		52.2

* 188:20 hours not 235:25 hours.

PERIOD NO. 5 - TWO 10-MINUTE RESTS

9-12-27	8:25		464		500		479		466		467		475
9-13	8:25		461		502		475		468		453		472
9-14	8:25	460	433	445	418	458	450	442	431	436	416	448	430
9-15	8:25		460		491		454		451		457		463
9-16	8:25	445	436	434	407	461	461	445	445	478	459	453	442
9-17	4:05	(450)	218	(471)	228	(537)	260	(491)	238	(456)	221	(481)	233
Total	46:10		2472		2546		2579		2499		2473		2515
9-19-27	8:25		440		444		483		454		464		457
9-20	8:25		430		437		486		458		455		453
9-21	8:25	441	423	438	423	510	495	412	502	457	430	472	455
9-22	8:25		469		472		493		471		471		475
9-23	8:25	456	450	455	448	516	516	516	516	454	433	479	473
9-24	4:05	(466)	226	(464)	225	(489)	237	(468)	227	(417)	202	(461)	223
Total	46:10		2438		2449		2710		2628		2455		2536

Date	Hr. & Min. Worked	1		2		3		4		5		Av. for Group	
9-26-27	8:25		441		494		460		450		461		461
9-27	8:25		479		501		490		490		469		486
9-28	8:25	481	468	483	459	465	443	476	468	402	372	461	442
9-29	8:25		504		498		476		473		449		480
9-30	8:25	473	461	450	437	491	476	465	454	448	439	465	453
10- 1	4:05	(462)	224	(479)	232	(501)	243	(501)	243	(421)	204	(473)	229
Total	46:10		2577		2621		2588		2578		2394		2551
10- 3-27	8:25		475		498		490		475		456		479
10- 4	8:25		470		491		488		499		465		483
10- 5	8:25	461	438	488	468	498	489	497	482	456	443	480	464
10- 6	8:25		465		478		494		490		453		476
10- 7	8:25	450	439	480	469	485	484	503	502	434	425	470	464
10- 8	4:05	(475)	230	(427)	207	(490)	237	(475)	230	(425)	206	(458)	222
Total	46:10		2517		2611		2682		2678		2448		2588
Period	184:40		10004		10227		10559		10383		9770		10190
Av.Hr.Output			54.2		55.4		57.2		56.2		52.9		55.1
PERIOD NO. 6 - SIX 5-MINUTE RESTS													
10-10-27	8:15		469		468		477		465		457		467
10-11	8:15		492		502		484		431		472		476
10-12	8:15	455	431	491	472	464	450	470	463	461	425	468	448
10-13	8:15		472		460		460		458		410		452
10-14	8:15	479	460	467	455	444	426	470	462	456	414	463	444
10-15	4:00	(460)	223	(460)	223	(415)	201	(439)	213	(437)	212	(442)	214
Total	45:15		2547		2580		2498		2493		2390		2501
10-17-27	8:15		441		462		390		433		456		436
10-18	8:15		485		511		471		484		466		483
10-19	8:15	479	446	486	456	499	480	497	484	438	429	480	459
10-20	8:15		471		468		477		485		482		477
10-21	8:15	441	431	427	419	463	458	476	471	483	442	458	444
10-22	4:00	(439)	213	(425)	206	(483)	234	(491)	238	(466)	226	(461)	223
Total	45:15		2487		2522		2510		2595		2501		2522
10-24-27	8:15		451		443		469		476		455		459
10-25	8:15		470		460		484		489		446		470
10-26	8:15	456	445	412	401	461	451	469	460	439	419	447	435
10-27	8:15		439		417		472		462		477		453
10-28	8:15	440	430	438	425	461	458	443	443	461	455	449	442
10-29	4:00	(429)	208	(425)	206	(507)	246	(446)	216	(437)	212	(449)	218
Total	45:15		2443		2352		2580		2546		2464		2477
10-31-27	8:15		444		455		433		441		473		449
11- 1	8:15		437		443		489		478		472		464
11- 2	8:15	465	435	439	410	507	497	491	484	466	443	474	454
11- 3	8:15		474		462		525		523		466		490
11- 4	8:15	471	462	444	432	515	512	494	490	427	417	470	463
11- 5	4:00	(448)	217	(404)	196	(499)	242	(464)	225	(427)	207	(448)	217
Total	45:15		2469		2398		2698		2641		2478		2537
Period	181:00		9946		9852		10286		10275		9833		10037
Av.Hr.Output			55.0		54.5		56.8		56.7		54.3		55.5

Date	Hr. & Min. Worked	1		2		3		4		5		Av. for Group	
	PERIOD NO. 7 - 15-MINUTE A.M. LUNCH, 10-MINUTE P.M. REST												
11- 7-27	8:20		437		456		480		487		450		462
11- 8	8:20		472		457		494		468		451		468
11- 9	8:20	469	450	458	434	495	481	480	477	474	452	475	459
11-10	8:20		473		478		478		441		475		469
11-11	8:20	458	448	420	410	475	462	449	439	448	436	450	439
11-12	4:00	(459)	220	(444)	213	(475)	228	(459)	220	(450)	216	(457)	219
Total	45:40		2500		2448		2623		2532		2480		2516
11-14-27	8:20		450		489		467		441		472		464
11-15	8:20		448		466		487		440		458		460
11-16	8:20	447	441	449	424	460	444	455	447	464	443	455	440
11-17	8:20		477		509		510		512		479		497
11-18	8:20	464	455	470	463	510	502	513	510	470	463	485	479
11-19	4:00	(473)	227	(431)	207	(482)	231	(471)	226	(463)	222	(464)	223
Total	45:40		2498		2558		2641		2576		2537		2563
11-21-27	8:20		422		446		470		441		466		449
11-22	8:20		485		482		476		472		458		475
11-23	8:20	478	443	471	460	489	479	475	474	471	448	477	461
11-24	"8:20"		"459"		"462"		"482"		"470"		"454"		"465"
11-25	8:20	497	494	469	469	498	495	487	487	448	442	480	477
11-26	4:00	(448)	215	(442)	212	(500)	240	(475)	228	(456)	219	(464)	223
Total	45:40		2518		2531		2642		2572		2487		2550
11-28-27	8:20		469*		481		465		473		469		471
11-29	8:20		479*		481		506		473		456		479
11-30	8:20	483	466*	487	471	479	479	473	473	461	445	477	467
12- 1	8:20		476*		479		492		472		462		476
12- 2	8:20	463	457*	468	446	476	474	477	474	465	450	470	460
12- 3	4:00	(475)	228*	(473)	227	(469)	225	(456)	219	(440)	211	(463)	222
Total	45:40		2575		2585		2641		2584		2493		2575
12- 5-27	8:20		441		477		463		432		432		449
12- 6	8:20		447		469		479		474		446		463
12- 7	8:20	469	466	480	470	491	484	476	473	474	458	478	470
12- 8	8:20		448		450		442		454		447		448
12- 9	8:20	482	471	442	432	464	462	474	473	432	423	459	452
12-10	4:00	(450)	216	(435)	209	(435)	209	(460)	221	(442)	212	(444)	213
Total	45:40		2489		2507		2539		2527		2418		2495
12-12-27	8:20		440		480		480		474		432		461
12-13	8:20		457		455		466		472		452		460
12-14	8:20	451	439	444	433	509	500	504	501	473	457	476	466
12-15	8:20		452		454		504		493		452		471
12-16	8:20	451	439	476	457	502	498	501	500	454	449	477	469
12-17	4:00	(433)	208	(427)	205	(473)	227	(492)	236	(375)	180	(440)	211
Total	45:40		2435		2484		2675		2676		2422		2538
12-19-27	8:20		411		433		456		476		457		447
12-20	8:20		413		419		500		495		451		456
12-21	8:20	424	406	450	429	505	496	510	504	472	450	472	457
12-22	8:20		384		379		478		473		447		432
12-23	8:20	446	437	433	420	478	472	501	496	420	418	456	449
12-24	4:00	(410)	197	(398)	191	(427)	205	(481)	231	(429)	206	(429)	206
Total	45:40		2248		2271		2607		2675		2429		2447

Date	Hr. & Min. Worked	Operators 1		2		3		4		5		Av. for Group
12-26-27	"8:20"	"446"		"437"		"488"		"508"		"449"		"466"
12-27	8:20	427		420		457		485		434		445
12-28	8:20	431	423	419	402	508	501	530	527	443	427	466	456
12-29	8:20	477		479		505		529		479		494
12-30	8:20	454	446	450	448	494	488	498	495	456	451	470	466
12-31	"4:00"	"(444)"	"213"	"(438)"	"210"	"(488)"	"234"	"(508)"	"244"	"(448)"	"215"	"(465)"	"223"
Total	45:40		2432		2396		2673		2788		2455		2550
1- 2-28	"8:20"	"444"		"434"		"498"		"493"		"466"		"467"
1- 3	8:20	433		441		483		491		467		463
1- 4	8:20	457	450	415	405	519	516	510	499	464	462	473	466
1- 5	8:20	431		427		499		493		470		464
1- 6	8:20	448	445	462	459	493	493	495	495	483	474	476	473
1- 7	4:00	(473)	227	(435)	209	(496)	238	(479)	230	(438)	210	(464)	223
Total	45:40		2430		2375		2727		2701		2549		2556
1- 9-28	8:20		469		439		488		493		458		469
1-10	8:20		463		400		529		524		454		474
1-11	8:20	460	455	449	432	501	488	494	490	460	446	473	462
1-12	8:20		473		458		528		511		483		491
1-13	8:20	448	436	438	427	531	527	507	503	457	443	476	467
1-14	4:00	(410)	197	(410)	197	(529)	254	(506)	243	(463)	222	(464)	223
Total	45:40		2495		2353		2814		2664		2506		2536
1-16-28	8:20		457		499		526		525		468		495
1-17	8:20		471		485		525		527		468		495
1-18	8:20	456	446	486	473	527	523	530	527	460	444	492	483
1-19	8:20		465		475		537		527		471		495
1-20	8:20	446	439	428	419	494	486	502	498	437	426	461	454
1-21	4:00	(413)	198	(421)	202	(521)	250	(515)	247	(456)	219	(465)	223
Total	45:40		2476		2553		2847		2851		2496		2645
Period	502:20		27096		27061		29429		29146		27272		28021
Av.Hr.Output			53.9		53.8		58.6		57.9		54.3		55.8

* Substitute

PERIOD NO. 8 - SAME AS NO. 7 BUT 4:30 STOP*

1-23-28	7:50		455		426		499		486		458		465
1-24	7:50		465		440		502		495		449		470
1-25	7:50	478	470	468	465	511	506	496	495	416	400	474	467
1-26	7:50		487		494		454		477		453		473
1-27	7;50	515	488	518	499	488	481	480	475	450	444	490	477
1-28	4:00	(503)	257	(509)	260	(468)	239	(485)	248	(415)	212	(476)	243
Total	43:10		2622		2584		2681		2676		2416		2595
1-30-28	7:50		492		508		476		497		451		485
1-31	7:50		511		513		491		495		452		492
2- 1	7:50	526	482	528	504	496	476	505	502	445	433	500	479
2- 2	7:50		506		519		494		500		459		496
2- 3	7:50	506	491	507	492	495	489	506	502	456	448	494	484
2- 4	4:00	(468)	239	(507)	259	(454)	232	(484)	247	(411)	210	(465)	237
Total	43:10		2721		2795		2658		2743		2453		2673

Date	Hr. & Min. Worked	Operators 1		2		3		4		5		Av. for Group	
2- 6-28	7:50		482		481		459		488		453		473
2- 7	7:50		502		516		506		513		452		498
2- 8	7:50	495	454	526	492	489	460	495	484	437	405	488	459
2- 9	7:50		524		532		498		502		433		498
2-10	7:50	506	496	521	513	497	488	514	514	458	445	499	491
2-11	4:00	(462)	236	(501)	256	(472)	241	(497)	254	(438)	224	(474)	242
Total	43:10		2694		2790		2652		2755		2412		2661
2-13-28	7:50		455		492		447		500		464		472
2-14	7:50		470		512		497		494		458		486
2-15	7:50	507	491	540	516	519	508	517	511	440	432	505	492
2-16	7:50		541		563		510		494		457		513
2-17	7:50	535	517	554	544	509	502	511	506	463	449	514	504
2-18	4:00	(487)	249	(505)	258	(475)	243	(491)	251	(421)	215	(476)	243
Total	43:10		2723		2885		2707		2756		2475		2710
2-20-28	7:50		460		480		480		498		462		476
2-21	7:50		476		515		494		495		466		489
2-22	7:50	496	466	508	490	495	476	503	499	462	434	493	473
2-23	7:50		501		511		466		497		466		488
2-24	7:50	518	490	522	509	516	516	513	513	457	453	505	496
2-25	4:00	(477)	244	(510)	261	(474)	242	(491)	251	(462)	236	(483)	247
Total	43:10		2637		2766		2674		2753		2517		2669
2-27-28	7:50		491		504		480		498		429		480
2-28	7:50		512		533		489		510		442		497
2-29	7:50	509	489	529	516	507	499	517	516	454	437	503	491
3- 1	7:50		521		531		511		497		456		503
3- 2	7:50	516	504	522	515	480	473	501	498	467	456	497	489
3- 3	4:00	(477)	244	(509)	260	(456)	235	(475)	243	(443)	226	(472)	241
Total	43:10		2761		2859		2685		2762		2446		2701
3- 5-28	7:50		486		517		483		488		455		486
3- 6	7:50		503		517**		509		488		443		492
3- 7	7:50	538	515	503	499**	513	499	518	513	431	428	501	491
3- 8	7:50		520		511**		491		488		448		492
3- 9	7:50	513	513	510	510**	474	474	476	476	430	421	481	479
3-10	4:00	(501)	256	(487)	243**	(475)	243	(484)	247	(424)	217	(474)	242
Total	43:10		2793		2803		2699		2700		2412		2682
Period	302:10		18951		19482		18756		19145		17131		18691
Av.Hr.Output			62.7		64.4		61.9		63.2		53.6		61.8

* Operators No. 1 and No. 2 replaced at beginning of this period
** Substitute

PERIOD NO. 9 - SAME AS NO. 7 BUT 4:00 STOP

3-12-28	7:20	466	451		499	455	447		469		444	467	462
3-13	7:20		472		506		452		472		448		470
3-14	7:20	498	476	508	494	488	473	484	483	400	399	476	465
3-15	7:20		491		506		479		480		470*		485
3-16	7:20	504	492	523	517	489	484	485	485	443	439	489	483
3-17	4:00	(462)	252	(488)	266	(469)	256	(462)	252	(436)	238	(463)	253
Total	40:40		2634		2788		2591		2641		2438		2618

Date	Hr. & Min. Worked		1		2		3		4		5		Av. for Group
					Operators								
3-19-28	7:20		461		471		469		481		458		468
3-20	7:20		489		510		466		479		434		476
3-21	7:20	481	456	496	484	474	461	480	470	457	448	478	464
3-22	7:20		490		503		483		477		454		481
3-23	7:20	484	473	499	491	472	464	471	471	455	450	476	470
3-24	4:00	(471)	257	(493)	269	(464)	253	(455)	248	(440)	240	(465)	253
Total	40:40		2626		2728		2596		2626		2484		2612
3-26-28	7:20		477		498		430		469		447		464
3-27	7:20		470		483		454		448		409		453
3-28	7:20	496	476	529	517	486	473	470	460	436	421	483	469
3-29	7:20		488		505		476		472		423		473
3-30	7:20	492	482	512	502	476	471	472	472	429	418	476	469
3-31	4:00	(480)	262	(486)	265	(460)	251	(464)	253	(414)	226	(461)	251
Total	40:40		2655		2770		2555		2574		2344		2579
4- 2-28	7:20		482		476		458		456		443		463
4- 3	7:20		500		504		466		461		454		477
4- 4	7:20	496	486	510	504	442	440	452	448	428	415	466	459
4- 5	7:20		512		517		464		454		454		480
4- 6	7:20	513	501	521	511	466	461	458	458	462	454	484	477
4- 7	4:00	(486)	265	(513)	280	(429)	234	(427)	233	(429)	234	(457)	249
Total	40:40		2746		2792		2523		2510		2454		2605
Period	162:40		10661		11078		10265		10351		9720		10414
Av.Hr.Output			65.5		68.0		63.1		63.7		59.7		64.1

* Substitute

PERIOD NO. 10 - SAME AS NO. 7 (CHECK)

4- 9-28	8:20		553		547		502		488		491		516
4-10	8:20		533		539		497		497		480		509
4-11	8:20	544	527	561	542	530	517	514	508	478	459	525	511
4-12	8:20		561		572		519		507		467		525
4-13	8:20	554	538	594	581	530	526	531	528	477	462	537	527
4-14	4:00	(600)	288	(606)	291	(527)	253	(511)	245	(471)	226	(543)	261
Total	45:40		3000		3072		2814		2773		2585		2849
4-16-28	8:20		550		545		503		512		489		520
4-17	8:20		569		576		511		490		503		530
4-18	8:20	589	580	603	597	524	517	529	529	486	469	546	538
4-19	8:20		579		597		515		505		477		535
4-20	8:20	569	552	574	564	512	504	517	513	494	476	533	522
4-21	4:00	(550)	264	(569)	273	(529)	254	(511)	245	(486)	233	(529)	254
Total	45:40		3094		3152		2804		2794		2647		2899
4-23-28	8:20		553		557		496		510		462		516
4-24	8:20		542		530		495		505		476		510
4-25	8:20	529	516	537	530	490	485	502	501	485	466	509	500
4-26	8:20		496		501		488		489		477		490
4-27	8:20	503	491	512	506	501	493	514	508	475	467	501	493
4-28	4:00	(502)	241	(527)	253	(477)	229	(496)	238	(482)	231	(497)	238
Total	45:40		2839		2877		2686		2751		2580		2747

Date	Hr. & Min. Worked	Operators 1		2		3		4		5		Av. for Group
4-30-28	8:20		493		590		501		502		476	498
5- 1	8:20		529		530		500		490		457	501
5- 2	8:20	546	531	545	526	529	511	536	532	486	477	528	515
5- 3	8:20		532		553		504		532		445		513
5- 4	8:20	552	552	543	534	518	506	529	526	462	448	521	513
5- 5	4:00	(552)	265	(533)	256	(509)	244	(521)	520	(480)	230	(519)	249
Total	45:40		2902		2919		2766		2832		2533		2789
5- 7-28	8:20		514		522		560		540		459		519
5- 8	8:20		494		524		550		505		454		505
5- 9	8:20	518	499	532	518	528	521	513	512	439	431	506	496
5-10	8:20		503		532		509		494		468		501
5-11	8:20	515	504	547	537	519	515	516	515	471	468	514	508
5-12	4:00	(485)	233	(504)	242	(510)	245	(522)	251	(474)	228	(499)	240
Total	45:40		2747		2875		2900		2817		2508		2769
5-14-28	8:20		509		509		527		532		475		510
5-15	8:20		501		505		507		506		475		499
5-16	8:20	503	488	534	516	518	510	534	533	471	459	512	501
5-17	8:20		530		546		504		512		482		515
5-18	8:20	534	522	557	549	541	536	531	531	447	435	522	515
5-19	4:00	(531)	255	(576)	277	(522)	251	(529)	254	(460)	221	(524)	252
Total	45:40		2805		2902		2835		2868		2547		2792
5-21-28	8:20		516		525		538		535		479		519
5-22	8:20		524		543		554		542		434		519
5-23	8:20	510	491	532	517	559	550	550	546	416	407	513	502
5-24	8:20		534		534		539		541		427		515
5-25	8:20	536	524	541	534	547	546	526	526	426	423	515	511
5-26	4:00	(508)	244	(527)	253	(512)	246	(539)	259	(390)	187	(495)	238
Total	45:40		2833		2906		2973		2949		2357		2804
5-28-28	8:20		519		518		494		524		476		506
5-29	8:20		542		558		513		533		436		516
5-30	"8:20"		"538"		"541"		"516"		"535"		"443"		"515"
5-31	8:20		555		550		545		555		439		525
6- 1	8:20	556	543	581	565	512	504	531	531	424	418	521	512
6- 2	4:00	(525)	252	(522)	251	(527)	253	(527)	253	(454)	218	(511)	245
Total	45:40		2949		2963		2825		2931		2430		2819
6- 4-28	8:20		550		562		513		548		477		530
6- 5	8:20		558		573		514		547		432		525
6- 6	8:20	566	559	569	560	537	527	553	552	456	445	536	529
6- 7	8:20		548		562		545		564		478		539
6- 8	8:20	550	539	540	532	560	556	545	544	570	469	533	528
6- 9	4:00	(529)	254	(573)	275	(518)	249	(529)	254	(444)	213	(519)	249
Total	45:40		3008		3064		2904		3009		2514		2900
6-11-28	8:20		528		549		496		523		479		515
6-12	8:20		549		570		548		550		489		541
6-13	8:20	541	524	545	531	516	509	530	526	474	467	521	511
6-14	8:20		536		507		505		532		438		504
6-15	8:20	535	522	539	523	547	540	550	545	465	460	527	518
6-16	4:00	(541)	260	(541)	260	(518)	249	(529)	254	(475)	228	(521)	250
Total	45:40		2919		2940		2847		2930		2561		2839

Date	Hr. & Min. Worked		1		2		3		4		5		Av. for Group
6-15-28	8:20		542		546		511		531		474		521
6-19	8:20		565		563		523		539		454		529
6-20	8:20	544	528	554	536	508	503	535	535	472	460	523	512
6-21	8:20		550		560		538		522		475		529
6-22	8:20	537	515	552	544	555	550	542	540	478	474	533	525
6-23	4:00	(550)	264	(537)	258	(525)	252	(520)	250	(450)	216	(516)	248
Total	45:40		2964		3007		2877		2917		2553		2864
6-25-28	8:20		523		537		519		517		477		515
6-26	8:20		555		567		533		534		484		535
6-27	8:20	538	519	515	497	485	478	505	501	457	440	500	487
6-28	8:20		565		530		510		535		418		512
6-29	8:20	584	584	564	553	514	509	526	526	428	423	523	519
6-30	4:00	(550)	264	(571)	274	(531)	255	(485)	233	(418)	201	(511)	245
Total	45:40		3010		2958		2804		2846		2443		2813
Period	548:00		35070		35635		34035		34417		30258		33884
Av.Hr.Output			64.0		65.0		62.1		62.8		55.2		61.9
PERIOD NO. 11 - SAME AS NO. 7 BUT SAT. A.M. OFF													
7-2-28	8:20		551		557		482		487		454		506
7-3	8:20	561	547	577	554	543	530	502	502	454	450	527	517
7-4	8:20		"552"		"563"		"527"		"514"		"440"		"519"
7-5	8:20		532		542		538		533		430		515
7-6	8:20	565	542	579	569	548	540	535	535	421	413	530	520
7-7													
Total	41:40		2724		2785		2617		2571		2187		2577
7-9-28	8:20		522		530		540		527		411		506
7-10	8:20		548		556		550		546		442		528
7-11	8:20	550	526	552	533	562	550	510	500	468	447	528	511
7-12	8:20		566		568		533		520		484		534
7-13	8:20	556	542	557	547	560	554	552	548	437	436	532	525
7-14													
Total	41:40		2704		2734		2727		2641		2220		2604
7-16-28	8:20		540		549		545		530		481		529
7-17	8:20		555		558		549		524		460		529
7-18	8:20	561	546	574	557	551	546	541	535	462	457	538	528
7-19	8:20		563		578		537		523		423		525
7-20	8:20	584	569	577	562	537	532	538	536	437	427	535	525
7-21													
Total	41:40		2773		2804		2709		2648		2248		2636
7-23-28	8:20		550		544		508		526		500		526
7-24	8:20		578		590		549		532		422		534
7-25	8:20	566	550	578	569	527	520	531	527	496	487	540	531
7-26	8:20		573		568		527		517		465		530
7-27	8:20	542	518	553	543	525	512	511	508	460	460	518	508
7-28													
Total	41:40		2769		2814		2616		2610		2334		2629

Date	Hr. & Min. Worked	1		2		3		4		5		Av. for Group
7-30-28		Vacation		Vacation		Vacation		Vacation		Vacation		
7-31		"		"		"		"		"		
8- 1		"		"		"		"		"		
8- 2		"		"		"		"		"		
8- 3		"		"		"		"		"		
8- 4		"		"		"		"		"		
8- 6-28		"		"		"		"		"		
8- 7		"		"		"		"		"		
8- 8		"		"		"		"		"		
8- 9		"		"		"		"		"		
8-10		"		"		"		"		"		
8-11		"		"		"		"		"		
8-13-28	8:20		508		508		516		481		411	485
8-14	8:20		548		553		532		530		435	520
8-15	8:20	545	536	553	538	559	552	550	550	447	441	531 523
8-16	8:20		543		562		561		529		456	530
8-17	8:20	539	529	514	506	562	560	547	545	450	444	522 517
8-18												
Total	41:40		2664		2667		2721		2635		2187	2575
8-20-28	8:20		535		525		514		516		481	514
8-21	8:20		591		600		551		539		500	556
8-22	8:20	587	569	588	576	543	534	522	513	496	487	547 536
8-23	8:20		593		599		546		529		494	552
8-24	8:20	365	547	573	560	546	640	540	535	497	493	544 535
8-25												
Total	41:40		2835		2860		2685		2632		2455	2693
8-27-28	8:20		557		558		529		542		483	534
8-28	8:20		544		562		536		549		497	538
8-29	8:20	548	507	557	520	533	526	540	519	483	483	532 511
8-30	8:20		571		582		502		521		490	533
8-31	8:20	542	520	552	535	513	506	513	509	484	484	521 511
9- 1												
Total	41:40		2699		2757		2599		2640		2437	2627
Period	291:40		19168		19421		18674		18377		16068	18341
Av.Hr.Output			65.7		66.6		64.0		63.0		55.1	62.9

	PERIOD NO. 12 - SAME AS NO. 3 (NO LUNCHES OR RESTS)												
9-3-28	"8:45"		"539"		"551"		"545"		"549"		"496"		"536"
9-4	8:45		520		528		526		536		502		522
9-5	8:45	560	547	550	545	542	539	548	546	512	508	542	537
9-6	8:45		534		555		531		522		486		526
9-7	8:45	538	531	557	540	566	561	587	586	488	483	547	542
9-8	4:15	(545)	265	(581)	282	(575)	279	(554)	269	(492)	239	(549)	267
Total	48:00		2936		3009		2981		3008		2714		2930

Date	Hr. & Min. Worked		1		2		3		4		5		Av. for Group
						Operators							
9-10-28	8:45		522		531		496		531		467		509
9-11	8:45		540		572		541		563		504		544
9-12	8:45	554	539	555	539	551	531	543	542	505	500	542	530
9-13	8:45		558		565		538		540		493		539
9-14	8:45	562	547	570	555	537	530	550	550	478	478	539	532
9-15	4:15	(527)	256	(537)	261	(573)	278	(546)	265	(480)	233	(553)	259
Total	48:00		2962		3023		2914		2991		2675		2913
9-17-28	8:45		531		552		524		543		487		527
9-18	8:45		559		570		514		529		505		535
9-19	8:45	570	546	570	561	540	526	545	545	501	501	545	536
9-20	8:45		537		553		531		535		498		531
9-21	8:45	585	557	583	553	518	509	539	539	431	431	531	518
9-22	4:15	(567)	275	(578)	281	(584)	283	(578)	281	(466)	227	(555)	269
Total	48:00		3005		3070		2887		2972		2649		2916
9-24-28	8:45		532		542		528		523		451		515
9-25	8:45		548		555		475		506		520		521
9-26	8:45	559	528	563	539	527	523	528	526	512	503	538	524
9-27	8:45		544		568		543		540		488		537
9-28	8:45	562	552	567	556	541	536	539	539	490	490	540	535
9-29	4:15	(550)	367	(584)	283	(511)	248	(552)	268	(456)	222	(531)	258
Total	48:00		2971		3043		2853		2902		2674		2890
10-1-28	8:45		524		529		519		508		503		517
10-2	8:45		550		557		528		529		514		536
10-3	8:45	561	548	572	560	564	559	569	564	508	500	555	546
10-4	8:45		567		584		530		548		500		546
10-5	8:45	565	556	581	571	551	548	540	538	490	486	545	540
10-6	4:15	(571)	278	(592)	288	(584)	284	(546)	265	(513)	249	(561)	273
Total	48:00		3023		3089		2968		2952		2752		2958
10-8-28	8:45		546		544		538		544		495		533
10-9	8:45		560		568		551		554		513		549
10-10	8:45	557	536	567	545	569	557	568	566	518	509	556	543
10-11	8:45		558		583		513		545		493		538
10-12	8:45	550	546	567	555	517	513	542	538	484	484	532	527
10-13	4:15	(564)	274	(571)	277	(467)	227	(509)	247	(418)	203	(506)	246
Total	48:00		3020		3072		2898		2994		2697		2936
10-15-28	8:45		529		534		471		535		514		517
10-16	8:45		571		582		511		537		511		542
10-17	8:45	540	517	546	528	527	517	544	537	508	500	533	520
10-18	8:45		584		598		530		548		508		554
10-19	8:45	580	570	591	584	495	491	523	521	505	505	539	534
10-20	4:15	(545)	265	(551)	268	(516)	251	(533)	259	(495)	241	(528)	257
Total	48:00		3036		3094		2771		2957		2779		2924
10-22-28	8:45		511		527		471		516		476		500
10-23	8:45		514		530		520		539		486		518
10-24	8:45	525	514	549	538	511	505	543	540	479	479	521	515
10-25	8:45		584		588		531		552		475		546
10-26	8:45	570	564	578	564	524	521	546	544	477	477	539	534
10-27	4:15	(577)	280	(597)	290	(490)	238	(519)	252	(527)	256	(542)	263
Total	48:00		2967		3037		2786		2943		2649		2876

Date	Hr. & Min. Worked		1		2		3		4		5		Av. for Group
10-29-28	8:45		543		558		512		519		517		530
10-30	8:45		521		534		514		516		507		518
10-31	8:45	536	519	537	526	523	519	541	539	520	520	531	525
11-1	8:45		539		536		523		534		480		526
11-2	8:45	540	536	557	553	536	535	539	538	511	511	537	535
11-3	4:15	(556)	270	(593)	288	(533)	259	(517)	251	(447)	217	(529)	257
Total	48:00		2928		3015		2862		2897		2752		2891
11-5-28	8:45		531		534		523		533		512		527
11-6	8:45		563		570		512		514		486		529
11-7	8:45	578	571	600	591	538	531	535	532	480	479	546	541
11-8	8:45		563		540		533		517		451		521
11-9	8:45	526	521	539	534	549	545	554	553	504	499	534	530
11-10	4:15	(558)	371	(601)	292	(494)	240	(533)	359	(455)	221	(528)	257
Total	48:00		3020		3061		2884		2908		2648		2905
11-12-28	8:45		531		533		440		504		475		497
11-13	8:45		546		560		541		555		518		544
11-14	8:45	557	548	567	550	480	478	506	501	460	460	514	507
11-15	8:45		568		587		530		531		517		547
11-16	8:45	600	596	615	607	544	543	545	545	494	494	560	557
11-17	4:15	(571)	277	(601)	292	(552)	268	(558)	271	(502)	244	(557)	270
Total	48:00		3066		3129		2800		2907		2708		2922
11-19-28	8:45		542		543		504		510		501		520
11-20	8:45		560		581		525		532		475		535
11-21	8:45	559	545	579	568	506	504	516	516	492	492	530	525
11-22	8:45		553		578		500		533		425		518
11-23	8:45	573	570	593	582	506	503	532	532	"478"	"478"	536	533
11-24	8:45	(543)	264	(560)	272	(478)	232	(517)	251	(513)	249	(522)	254
Total	48:00		3034		3124		2768		2874		2620		2885
Period	576:00		35968		36776		34372		35285		32313		34946
Av.Hr.Output			62.4		63.8		59.5		61.3		56.1		60.6

PERIOD NO. 13 - SAME AS NO. 7 BUT OPERS. FURNISH OWN LUNCHES, CO. FURNISHES BEVERAGE

11-26-28	8:20		544		554		513		503		495		522
11-27	8:20		580		585		533		533		512		549
11-28	8:20	574	554	581	571	541	532	542	522	512	512	550	538
11-29	8:20		"551"		"561"		"516"		"515"		"501"		"529"
11-30	8:20	539	539	553	553	476	476	481	481	489	489	508	508
12-1	4:00	(486)	233	(498)	239	(521)	250	(519)	249	(487)	234	(502)	241
Total	45:40		3000		3063		2820		2803		2743		2887
12-3-28	8:20		543		556		534		538		493		533
12-4	8:20		569		588		528		536		507		546
12-5	8:20	571	559	551	532	550	541	540	535	500	500	542	583
12-6	8:20		586		610		557		545		507		561
12-7	8:20	576	562	586	580	558	556	550	547	508	508	556	551
12-8	4:00	(562)	270	(596)	286	(498)	239	(502)	241	(412)	198	(514)	247
Total	45:40		3089		3152		2955		2942		2713		2971

Date	Hr. & Min. Worked	Operators 1		2		3		4		5		Av. for Group	
12-10-28	8:20		505		551		516		526		490		518
12-11	8:20		518		577		511		533		502		528
12-12	8:20	460*	460*	574	560	541	537	560	557	512	507	529	524
12-13	8:20		549		569		515		532		519		537
12-14	8:20	530	530	551	545	503	498	527	523	506	506	523	520
12-15	4:00	(525)	252	(562)	270	(483)	232	(508)	244	(521)	250	(520)	250
Total	45:40		2814		3072		2809		2915		2774		2877
*Substitute													
12-17-28	8:20		526		534		494		535		518		520
12-18	8:20		543		554		521		557		478		531
12-19	8:20	574	551	578	559	513	500	561	552	517	517	549	536
12-20	8:20		580		600		492		546		517		547
12-21	8:20	596	581	619	613	526	523	557	555	529	529	565	560
12-22	4:00	(591)	284	(600)	288	(490)	235	(515)	247	(516)	248	(542)	260
	45:40		3065		3138		2765		2992		2807		2954
12-24-28	8:20		525		534		433		492		516		500
12-25	8:20		"555"		"570"		"493"		"520"		"513"		"530"
12-26	8:20	540	526	561	555	476	466	494	491	493	493	513	506
12-27	8:20		570		578		516		535		501		540
12-28	8:20	586	575	606	596	549	546	559	557	543	543	569	563
12-29	4:00	(555)	"266"	(570)	"274"	(493)	"237"	(520)	"250"	(513)	"246"	(530)	"255"
Total	45:40		3017		3107		2691		2845		2812		2894
12-31-28	8:20		531		552		481		527		498		518
1-1-29	8:20		"561"		"582"		"529"		"554"		"486"		"542"
1-2	8:20	556	555	581	581	544	539	535	535	504	504	544	543
1-3	8:20		556		575		539		574		491		547
1-4	8:20	595	588	613	611	553	548	577	574	465	465	561	557
1-5	4:00	(565)	271	(598)	287	(531)	255	(561)	269	(461)	221	(543)	261
Total	45:40		3062		3188		2891		3033		2665		2968
1-7-29	8:20		561		571		559		571		494		551
1-8	8:20		584		596		544		571		483		556
1-9	8:20	566	551	588	580	554	543	576	569	473	464	551	541
1-10	8:20		536		553		534		553		469		529
1-11	8:20	555	548	581	570	547	539	556	556	500	495	548	542
1-12	4:00	(533)	256	(563)	270	(531)	255	(527)	253	(419)	201	(515)	247
Total	45:40		3036		3140		2974		3073		2606		2966
1-14-29	8:20		524		538		522		554		489		525
1-15	8:20		563		574		549		569		508		553
1-16	8:20	542	524	583	562	559	548	586	580	475	471	549	537
1-17	8:20		555		580		537		567		496		547
1-18	8:20	563	544	571	568	544	541	575	575	507	474	552	540
1-19	4:00	(540)	259	(562)	270	(490)	235	(516)	248	(496)	238	(521)	250
Total	45:40		2969		3092		2932		3093		2676		2952

Date	Hr. & Min. Worked	Operators 1		2		3		4		5		Av. for Group	
1-21-29	8:20		551		565		505		516		486		525
1-22	8:20		563		601		557		576		474		554
1-23	8:20	585	558	612	595	569	557	587	578	488	472	568	552
1-24	8:20		574		593		555		580		474		555
1-25	8:20	551	527	577	566	573	563	586	581	484	481	554	544
1-26	4:00	(561)	269	(604)	290	(541)	260	(562)	270	(504)	242	(554)	266
Total	45:40		3042		3210		2997		3101		2629		2996
1-28-29	8:20		549		556		539		567		486		539
1-29	8:20		576		602		558		576		480		558
1-30	8:20	574	556	593	565	556	541	582	578	492	486	559	545
1-31	8:20		554		573		558		579		503		553
2-1	8:20	570	562	595	575	549	535	566	560	489	480	554	542
2-2	4:00	(540)	259	(569)	273	(541)	260	(590)	283	(466)	224	(541)	260
Total	45:40		3056		3144		2991		3143		2659		2997
2-4-29	8:20		552		576		524		547		489		538
2-5	8:20		582		606		545		569		486		558
2-6	8:20	613	596	644	630	535	521	562	545	491	482	569	555
2-7	8:20		591		619		576		592		497		575
2-8	8:20	603	589	631	624	568	568	608	604	508	508	584	579
2-9	4:00	(562)	270	(611)	293	(506)	243	(558)	268	(491)	236	(546)	262
Total	45:40		3180		3348		2977		3125		2698		3067
2-11-29	8:20		533		562		508		566		446		523
2-12	8:20		562		607		508		548		455		536
2-13	8:20	571	544	609	597	513	506	575	567	462	459	546	535
2-14	8:20		556		589		517		567		459		538
2-15	8:20	567	553	597	590	526	519	567	567	498	493	551	544
2-16	4:00	(587)	282	(629)	302	(550)	284	(558)	268	(436)	209	(552)	265
Total	45:40		3030		3247		2822		3083		2521		2941
2-18-29	8:20		543		610		536		568		456		543
2-19	8:20		588		632		542		570		510		568
2-20	8:20	588	577	655	642	556	549	603	603	505	501	581	574
2-21	8:20		581		619		569		604		529		580
2-22	8:20	531	515	592	581	559	557	601	601	520	520	561	555
2-25	4:00	(569)	273	(621)	298	(523)	251	(571)	274	(433)	208	(543)	261
Total	45:40		3077		3382		3004		3220		2724		3081
2-25-29	8:20		546		567		542		568		465		538
2-26	8:20		553		585		541		597		507		557
2-27	8:20	570	552	597	588	558	555	606	603	486	483	563	556
2-28	8:20		543		583		527		584		461		540
3-1	8:20	545	532	575	567	546	542	574	573	461	451	540	533
3-2	4:00	(521)	250	(589)	283	(554)	266	(560)	269	(468)	225	(538)	259
Total	45:40		2976		3173		2973		3194		2592		2983
3-4-29	8:20		522		561		559		577		494		543
3-5	8:20		544		564		545		585		512		550
3-6	8:20	566	551	601	587	533	514	578	575	493	484	554	542
3-7	8:20		570		615		545		567		478		555
3-8	8:20	564	554	611	591	551	547	609	609	507	497	568	560
3-9	4:00	(494)	237	(562)	270	(481)	231	(541)	260	(475)	228	(511)	245
Total	45:40		2978		3188		2941		3173		2693		2995

Date	Hr. & Min. Worked		1		2		3		4		5		Av. for Group
						Operators							
3-11-29	8:20		524		589		539		573		488		543
3-12	8:20		577		628		528		567		471		554
3-13	8:20	556	525	596	573	525	507	576	569	511	492	549	533
3-14	8:20		571		623		528		567		425		555
3-15	8:20	547	531	594	580	521	508	581	577	496	496	548	538
3-16	4:00	(558)	268	(598)	287	(521)	250	(561)	269	("490")	"235"	(546)	262
Total	45:40		2998		3280		2860		3122		2667		2985
3-18-29	8:20		552		585		567		584		493		556
3-19	8:20		591		624		545		602		507		574
3-20	8:20	609	602	642	634	531	524	591	586	502	502	575	570
3-21	8:20		593		622		527		569		505		563
3-22	8:20	593	587	627	619	530	528	575	573	504	504	566	562
3-23	4:00	(575)	276	(621)	298	(544)	261	(561)	269	(494)	237	(559)	268
Total	45:40		3201		3382		2932		3183		2748		3093
3-25-29	8:20		554		586		560		589		520		562
3-26	8:20		575		610		544		577		511		563
3-27	8:20	591	581	624	607	533	523	581	577	523	523	562	570
3-28	8:20		608		635		521		580		525		574
3-29	8:20	624	622	654	645	551	547	605	601	486	486	584	580
3-30	4:00	(555)	271	(612)	294	(481)	231	(552)	265	(475)	228	(537)	258
Total	45:40		3211		3377		2926		3189		2793		3107
4-1-29	8:20		566		584		512		565		468		539
4-2	8:20		533		580		501		567		470		530
4-3	8:20	536	526	586	575	500	494	586	579	467	461	535	527
4-4	8:20		536		582		520		570		487		539
4-5	8:20	535	559	621	618	564	562	598	598	487	487	567	565
4-6	4:00	(571)	273	(625)	300	(573)	275	(616)	296	(490)	235	(575)	276
Total	45:40		2993		3239		2864		3175		2608		2976
4-8-29	8:20		575		592		578		612		496		571
4-9	8:20		585		623		586		631		505		586
4-10	8:20	621	613	643	629	557	562	610	609	513	506	591	584
4-11	8:20		588		625		565		590		512		576
4-12	8:20	563	558	599	592	567	564	600	600	504	494	567	562
4-13	4:00	(585)	280	(619)	297	(577)	277	(596)	286	(479)	230	(571)	274
Total	45:40		3199		3358		3132		3328		2743		3153
4-15-29	8:20		537		587		575		606		510		563
4-16	8:20		574		607		551		598		491		564
4-17	8:20	581	562	622	607	549	538	606	602	469	455	565	553
4-18	8:20		578		640		574		630		464		577
4-19	8:20	564	555	624	613	539	552	604	600	481	477	566	559
4-20	4:00	(550)	264	(594)	285	(531)	255	(546)	262	(460)	221	(536)	257
Total	45:40		3070		3339		3043		3298		2618		3073
4-22-29	8:20		524		575		542		600		480		544
4-23	8:20		567		625		541		598		499		566
4-24	8:20	574	565	631	619	526	519	593	586	481	471	561	552
4-25	8:20		565		623		537		598		493		563
4-26	8:20	548	582	626	622	571	569	603	603	518	518	580	579
4-27	4:00	(546)	262	(611)	293	(573)	275	(606)	291	(511)	245	(569)	273
Total	45:40		3065		3357		2983		3276		2706		3077

Date	Hr. & Min. Worked	Operators 1		2		3		4		5		Av. for Group	
4-29-29	8:20		523		582		533		592		516		553
4-30	8:20		538		617		538		597		528		578
5-1	8:20	581	566	641	635	565	554	617	610	496	496	580	572
5-2	8:20		614		654		584		646		501		600
5-3	8:20	(621)	611	666	662	600	598	648	644	537	534	614	610
5-4	4:00	(594)	285	(631)	303	(586)	281	(611)	293	(315)	247	587	282
Total	45:40		3167		3453		3158		3382		2822		3185
5-6-29	8:20		574		606		584		604		513		576
5-7	8:20		592		643		601		631		497		593
5-8	8:20	600	592	651	647	587	585	629	628	510	510	595	592
5-9	8:20		598		641		589		615		504		589
5-10	8:20	562	559	616	602	546	532	597	593	502	502	565	558
5-11	4:00	(537)	258	(600)	288	(554)	266	(587)	282	(230)	479	(551)	265
Total	45:40		3173		3427		3157		3353		3005		3173

2. The Rate of Production - Hourly Output and Per Cent of Efficiency

From the preceding basic data the average hourly output has been computed each week for each operator. This weekly average hourly output has been compared with a similar figure for the base period to give an index of an increasing or decreasing rate of production in comparison with the base period. This index is expressed as a percentage and is called the per cent of efficiency. Table 1 presents these data for the operators individually.

Table 1A presents similar average figures for sub-divisions of the group. It may be recalled that original operators Nos. 1 and 2 were replaced at the beginning of the eighth period. Since that time Table 1A has carried the average for operators Nos. 3, 4, and 5 separately because the base periods for these two sub-groups were not comparable. The per cent of efficiency for operators Nos. 1 and 2 is based upon their performance during period No. 8.

The two graphs following Tables 1 and 1A give a visual representation of the changes in the hourly output rate week by week and by periods of work.

The table on page 33 presents the average hourly output by periods for each operator, expressed as a percentage of the operator's maximum speed. The figure used as an index of maximum speed is the operator's greatest single fifteen minute output during the first year of the study.

The graph following this table is a plot of the data presented in the table.

TABLE NO. 1

FIRST RELAY ASSELBLY GROUP

Average Hourly Output and Per Cent of Efficiency by Weeks and by Periods

Period	Hrs. of Work Per Wk.	No. of Wk. in Period	Oper. No. 1 Aver. Hourly Output	Oper. No. 1 % of Eff.	Oper. No. 2 Aver. Hourly Output	Oper. No. 2 % of Eff.	Oper. No. 3 Aver. Hourly Output	Oper. No. 3 % of Eff.	Oper. No. 4 Aver. Hourly Output	Oper. No. 4 % of Eff.	Oper. No. 5 Aver. Hourly Output	Oper. No. 5 % of Eff.	Group Aver. Hourly Output	Group % of Eff.
No. 1														
Base Period in Regular Department	48.00	1												
		2												
			50.5	100	49.7	100	49.7	100	49.7	100	48.3	100	49.7	100
No. 2														
Introduction to Test Room	48.00	1	47.6	94.3	45.6	91.7	50.2	101.0	52.9	106.4	48.0	99.4	48.9	98.6
		2	50.2	99.4	54.5	109.7	52.6	105.8	54.0	108.7	50.8	105.2	52.4	105.8
		3	47.3	93.7	45.9	92.3	50.0	100.6	50.8	102.2	47.9	99.2	48.4	97.6
		4	46.7	92.5	45.7	91.9	43.7	87.9	48.1	96.8	47.7	98.8	46.4	93.6
		5	47.2	93.5	48.9	98.4	51.0	102.6	49.9	100.4	50.1	103.7	49.4	99.7
			47.8	94.6	48.0	96.6	49.5	99.6	51.1	102.8	48.9	101.2	49.1	99.1
No. 3														
Special Gang Rate	48.00	1	47.4	93.9	48.9	98.4	51.6	103.8	50.0	100.6	50.4	104.3	49.7	100.2
		2	46.4	91.9	48.1	96.8	52.9	106.4	51.0	102.6	51.8	107.2	50.0	101.0
		3	44.4	87.9	46.6	93.8	52.5	105.6	Vac.	Vac.	50.1	103.7	48.4	97.8
		4	48.6	96.2	49.2	99.0	54.3	109.3	51.1	102.8	48.6	100.6	50.4	101.6
		5	47.5	94.1	51.2	103.0	54.5	109.7	53.8	108.2	52.1	107.9	51.8	104.6
		6	50.3	99.6	52.4	105.4	54.4	109.5	53.9	108.5	50.4	104.3	52.3	105.5
		7	52.1	103.2	53.3	107.2	54.3	109.3	52.9	106.4	50.9	105.4	52.7	106.3
		8	50.7	100.4	53.4	107.4	54.8	110.3	52.7	106.0	50.4	104.3	52.4	105.7
			48.4	95.8	50.4	101.4	53.6	107.8	52.2	104.8	50.5	104.5	51.0	102.8
No. 4														
Two 5 Minute Rests	47.08	1	52.9	104.8	Vac.	Vac.	53.1	106.8	52.6	105.8	51.0	105.6	52.4	105.8
		2	52.1	103.2	48.9	98.4	55.2	111.1	53.3	107.2	50.4	104.3	52.0	104.8
		3	49.9	98.8	50.6	101.8	Vac.	Vac.	54.5	109.7	50.2	103.9	51.3	103.6
		4	50.6	100.2	51.6	103.8	51.4	103.4	52.2	105.0	51.6	106.8	51.5	103.8
		5	52.2	103.4	51.9	104.4	54.9	110.5	55.2	111.1	Vac.	Vac.	53.6	107.4
			51.5	101.9	50.7	102.0	53.6	107.8	53.6	107.8	50.8	105.2	52.2	105.1

Period	Hrs. of Work Per Wk.	No. of Wk. in Period	Oper. No. 1 Aver. Hourly Output	Oper. No. 1 % of Eff.	Oper. No. 2 Aver. Hourly Output	Oper. No. 2 % of Eff.	Oper. No. 3 Aver. Hourly Output	Oper. No. 3 % of Eff.	Oper. No. 4 Aver. Hourly Output	Oper. No. 4 % of Eff.	Oper. No. 5 Aver. Hourly Output	Oper. No. 5 % of Eff.	Group Aver. Hourly Output	Group % of Eff.
No. 5														
Two 10 Min. Rests	46.17	1	54.2	107.3	56.4	113.5	56.0	112.7	54.4	109.5	54.2	112.2	55.0	111.0
		2	52.8	104.6	53.0	106.6	58.7	118.1	56.9	114.5	53.2	110.1	54.9	110.8
		3	55.8	110.5	56.8	114.3	56.1	112.9	55.8	112.3	51.9	107.5	55.3	111.5
		4	53.7	106.3	55.6	111.9	57.0	114.7	57.1	114.9	52.6	108.9	55.2	111.3
			54.1	107.1	55.4	111.4	56.9	114.5	56.1	112.8	52.9	109.5	55.1	111.2
No. 6														
Six 5 Min. Rests	46.17	1	55.2	109.3	55.9	112.5	54.1	108.9	54.0	108.7	51.8	107.2	54.2	109.3
		2	53.9	106.7	54.6	109.9	54.4	109.5	56.2	113.1	54.2	112.2	54.7	110.3
		3	53.2	105.3	51.4	103.4	55.9	112.5	55.3	111.3	53.7	111.2	53.9	108.7
		4	54.0	106.9	52.7	106.0	58.3	117.3	57.3	115.3	54.4	112.6	55.3	111.6
			54.0	106.9	53.6	107.9	55.7	112.0	55.7	112.1	53.5	110.8	54.5	110.0
No. 7														
15 Min. A.M. Lunch,	45.67	1	55.2	109.3	54.9	110.5	57.4	115.5	55.4	111.5	54.3	112.4	55.4	111.8
10 Min. P.M. Rest		2	54.9	108.7	56.0	112.7	57.8	116.3	56.4	113.5	55.6	115.1	56.1	113.3
		3	55.1	109.1	55.4	111.5	60.0	120.7	56.2	113.1	54.4	112.6	56.2	113.4
		4	56.4	111.7	56.6	113.9	57.8	116.3	56.6	113.9	54.6	113.0	56.4	113.9
		5	54.7	108.3	55.2	111.1	55.7	112.1	54.9	110.5	53.4	110.6	54.8	110.4
		6	53.3	105.5	52.9	106.4	58.6	117.9	58.6	117.9	50.4	104.3	54.8	110.4
		7	49.4	97.8	49.7	100.0	57.7	116.1	58.6	117.9	53.2	110.1	53.7	108.4
		8	53.4	105.7	52.6	105.8	58.7	118.1	61.3	123.3	53.9	111.6	56.0	112.9
		9	53.3	105.5	52.2	105.0	59.7	120.1	59.2	119.1	56.0	115.9	56.1	113.1
		10	55.0	108.9	51.9	104.4	61.8	124.3	60.4	121.5	55.4	114.7	56.9	114.8
		11	54.5	107.9	56.3	113.3	62.6	126.0	62.5	125.8	55.0	113.9	58.2	117.4
			54.0	106.9	53.9	108.5	58.9	118.5	58.2	117.0	54.2	112.2	55.9	112.7
No. 8*														
15 Min. A.M. Lunch,	43.17	1	60.7	96.6	59.9	93.8	62.1	124.9	62.0	124.7	56.0	115.9	Group figures	
10 Min. P.M. Rest,		2	63.0	100.3	64.7	100.3	61.6	123.9	63.5	127.8	56.8	117.6	discontinued	
4:30 Stop		3	62.4	99.4	64.6	100.1	60.4	121.5	62.5	125.8	55.9	115.7	because of	
		4	62.8	100.0	66.7	103.4	62.8	126.4	63.6	128.0	57.3	118.6	replacement	
		5	62.0	98.7	64.5	100.0	63.8	128.4	63.7	128.2	58.8	121.7	of opers.1&2	
		6	64.0	101.9	66.2	102.6	62.2	125.2	64.0	128.8	56.7	117.4		
		7	64.8	103.2	65.1	100.9	62.6	126.0	62.6	126.0	56.2	116.4		
			62.8	100.0	64.5	100.0	62.2	125.1	63.1	127.0	56.8	117.6		

* Operators Nos. 1 & 2 replaced at beginning of this period.

Period	Hrs. of Work Per Wk.	No. of Wk. in Period	Oper. No. 1 Aver. Hourly Output	Oper. No. 1 % of Eff.	Oper. No. 2 Aver. Hourly Output	Oper. No. 2 % of Eff.	Oper. No. 3 Aver. Hourly Output	Oper. No. 3 % of Eff.	Oper. No. 4 Aver. Hourly Output	Oper. No. 4 % of Eff.	Oper. No. 5 Aver. Hourly Output	Oper. No. 5 % of Eff.	Group Aver. Hourly Output	Group % of Eff.
No. 9														
15 Min. A.M. Lunch,	40.67	1	64.8	103.2	68.5	106.2	63.7	128.2	64.9	130.6	59.1	122.4		
10 Min. P.M. Rest,		2	64.5	102.7	67.0	103.8	63.8	128.4	64.5	129.8	61.0	126.3		
4:00 Stop		3	65.3	103.9	68.1	105.5	62.8	126.4	63.3	127.4	57.6	119.3		
		4	67.3	107.1	68.5	106.2	61.9	124.5	61.6	123.9	60.2	124.6		
			65.5	104.3	68.0	105.4	63.0	126.7	63.5	127,8	59.5	123.2		
No. 10														
15 Min. A.M. Lunch,	45.67	1	65,3	103.9	66.9	103.7	61.6	123.9	60.7	122.1	56.6	117.2		
10 Min. P.M. Rest		2	67.7	107.8	69.0	106.9	61.4	123.5	61.1	122.9	58.0	120.1		
Same as No. 7		3	62.2	99.0	62.9	97.5	58.8	118.3	60.2	121.1	56.5	117.0		
		4	63.5	101.1	63.8	98.9	60.5	121.7	62.0	124.7	55.7	115.3		
		5	60.1	95.7	62.9	97.5	64.0	128.8	61.7	124.1	54.9	113.7		
		6	61.3	97.6	63.3	98.1	61.9	124.5	62.7	126.1	55.7	115.3		
		7	62.0	98.7	63.6	98.6	65.1	131.0	64.6	129.9	51.6	106.8		
		8	64.6	102.8	64.9	100.6	61.8	124.3	64.2	129.2	53.0	109.7		
		9	65.8	104.7	67.1	104.0	63.6	127.9	65.9	132.6	55.4	114.7		
		10	63.9	101.7	64.4	99.8	62.3	125.3	64.2	129.2	56.7	117.4		
		11	64.9	103.3	65.7	101.8	62.9	126.5	63.8	128.3	55.7	115.3		
		12	65.5	104.3	64.5	100.0	61.2	123.1	62.1	124.9	53.3	110.3		
			63.9	101.7	64.9	100.6	62.1	124.9	62.8	126.3	55.2	114.3		
No. 11														
15 Minute A.M. Lunch,	41.67	1	65.1	103.7	66.6	103.2	62.6	125.9	61.7	124.2	52.3	108.3		
10 Min. P.M. Rest,		2	64.7	103.0	65.6	101.7	65.4	130.9	63.2	127.2	53.2	110.2		
Saturday A.M. off		3	66.5	105.9	67.3	104.3	65.0	130.8	63.4	127.6	53.9	111.6		
		4	66.4	105.7	67.5	104.6	62.7	126.2	62.6	125.9	56.0	115.9		
		5	Vac.	-	Vac.	-	Vac.	-	Vac.	-	Vac.	-		
		6	Vac.	-	Vac.	-	Vac.	-	Vac.	-	Vac.	-		
		7	63.7	101.4	63.5	98.4	65.1	130.9	63.0	126.7	52.4	108.5		
		8	68.0	108.2	68.5	106.2	64.4	129.5	63.1	126.9	58.9	121.9		
		9	64.7	103.0	66.1	102.5	62.3	125.3	63.2	127.2	58.4	120.9		
			65.6	104.4	66.4	103.0	63.9	128.5	62.9	126.5	55.0	113.9		

Period	Hrs. of Work Per Wk.	No. of Wk. in Period	Oper. No. 1 Aver. Hourly Output	Oper. No. 1 % of Eff.	Oper. No. 2 Aver. Hourly Output	Oper. No. 2 % of Eff.	Oper. No. 3 Aver. Hourly Output	Oper. No. 3 % of Eff.	Oper. No. 4 Aver. Hourly Output	Oper. No. 4 % of Eff.	Oper. No. 5 Aver. Hourly Output	Oper. No. 5 % of Eff.	Group Aver. Hourly Output	Group % of Eff.
No. 12														
No Lunches, No Rests Same as No. 3	48.00	1	61.1	97.3	62.7	97.2	62.2	125.2	62.7	126.2	56.5	116.9		
		2	61.7	98.2	62.9	97.5	60.7	122.1	62.3	125.3	55.7	115.3		
		3	62.6	99.6	63.9	99.1	60.1	120.9	61.9	124.5	55.2	114.3		
		4	61.9	98.7	63.4	98.3	59.4	118.3	60.5	123.0	55.7	114.3		
		5	63.0	100.5	64.4	99.8	61.8	123.1	61.5	125.0	57.3	117.7		
		6	62.9	100.3	64.0	99.2	60.4	120.3	62.4	126.8	56.2	115.4		
		7	63.3	101.0	64.5	100.0	57.7	114.9	61.2	124.4	57.9	118.9		
		8	61.8	98.6	63.3	98.1	58.0	115.5	61.3	124.6	55.2	113.3		
		9	61.0	97.3	62.8	97.4	59.6	118.7	60.4	122.8	57.3	117.7		
		10	62.9	100.3	63.8	98.9	60.1	119.7	60.6	123.2	55.2	113.3		
		11	63.9	101.9	65.2	101.1	58.3	116.1	60.6	123.2	56.4	115.7		
		12	63.2	100.8	65.1	100.9	57.7	114.9	59.9	121.7	54.6	112.1		
			62.5	99.7	63.9	99.1	59.7	118.9	61.3	124.6	56.1	115.2		
No. 13														
15 Min. A.M. Lunch, 10 Min. P.M. Rest. Operators furnish Lunch. Company Furnishes Beverage.	45.67	1	65.7	104.8	67.1	104.0	61.7	122.9	61.4	124.8	60.1	123.4		
		2	67.6	107.8	69.0	107.0	64.7	128.9	64.4	130.9	59.4	122.0		
		3	61.6	98.2	67.3	104.3	61.5	122.5	63.8	129.7	60.8	124.8		
		4	67.1	107.0	68.7	106.5	60.5	120.5	65.5	133.1	61.5	126.3		
		5	66.1	105.4	68.0	105.4	58.9	117.3	62.3	126.6	61.6	126.5		
		6	67.0	106.9	69.8	108.2	63.3	126.1	66.4	135.0	58.4	119.9		
		7	66.5	106.1	68.8	106.7	65.1	129.7	67.3	136.8	57.1	117.2		
		8	65.0	103.7	67.7	105.0	64.2	127.9	67.7	137.6	58.6	120.3		
		9	66.6	106.2	70.3	109.0	65.6	130.7	67.9	138.0	57.6	118.3		
		10	66.9	106.7	68.8	106.7	65.5	130.5	68.8	139.8	58.2	119.5		
		11	69.6	111.0	73.3	113.6	65.2	129.9	68.4	139.0	59.1	121.4		
		12	66.3	105.7	71.1	110.2	61.8	123.1	67.5	137.2	55.2	113.3		
		13	67.4	107.5	74.1	114.9	65.8	131.1	70.5	143.3	59.6	122.4		
		14	65.2	104.0	69.5	107.8	65.1	124.7	69.9	142.1	56.8	116.6		
		15	65.2	104.0	69.8	108.2	64.4	128.3	69.5	141.3	59.0	121.2		

Period	Hrs. of Work Per Wk.	No.of Wk.in Period	Oper. No. 1 Aver. Hourly Output	Oper. No. 1 % of Eff.	Oper. No. 2 Aver. Hourly Output	Oper. No. 2 % of Eff.	Oper. No. 3 Aver. Hourly Output	Oper. No. 3 % of Eff.	Oper. No. 4 Aver. Hourly Output	Oper. No. 4 % of Eff.	Oper. No. 5 Aver. Hourly Output	Oper. No. 5 % of Eff.	Group Aver. Hourly Output	Group % of Eff.
No. 13 Cont'd	45.67	16	65.6	104.6	71.8	111.3	62.6	124.7	68.4	139.0	58.4	119.9		
		17	70.1	111.8	74.1	114.9	64.6	128.7	69.7	141.7	60.2	123.6		
		18	70.3	112.1	73.9	114.6	64.1	127.7	69.8	141.9	61.1	125.5		
		19	65.5	104.5	70.9	109.9	62.7	124.9	69.5	141.3	57.1	117.2		
		20	70.0	111.6	73.5	114.0	68.5	136.5	72.9	148.2	60.1	123.4		
		21	67.2	107.2	73.1	113.3	66.6	132.7	72.2	146.7	57.3	117.7		
		22	67.1	107.0	73.5	114.0	65.3	130.1	71.7	145.7	59.3	121.8		
		23	69.1	110.2	75.6	117.2	69.1	137.6	74.1	150.6	61.8	126.9		
		24	69.5	110.8	75.0	116.3	69.1	137.6	73.4	149.2	65.5	134.5		

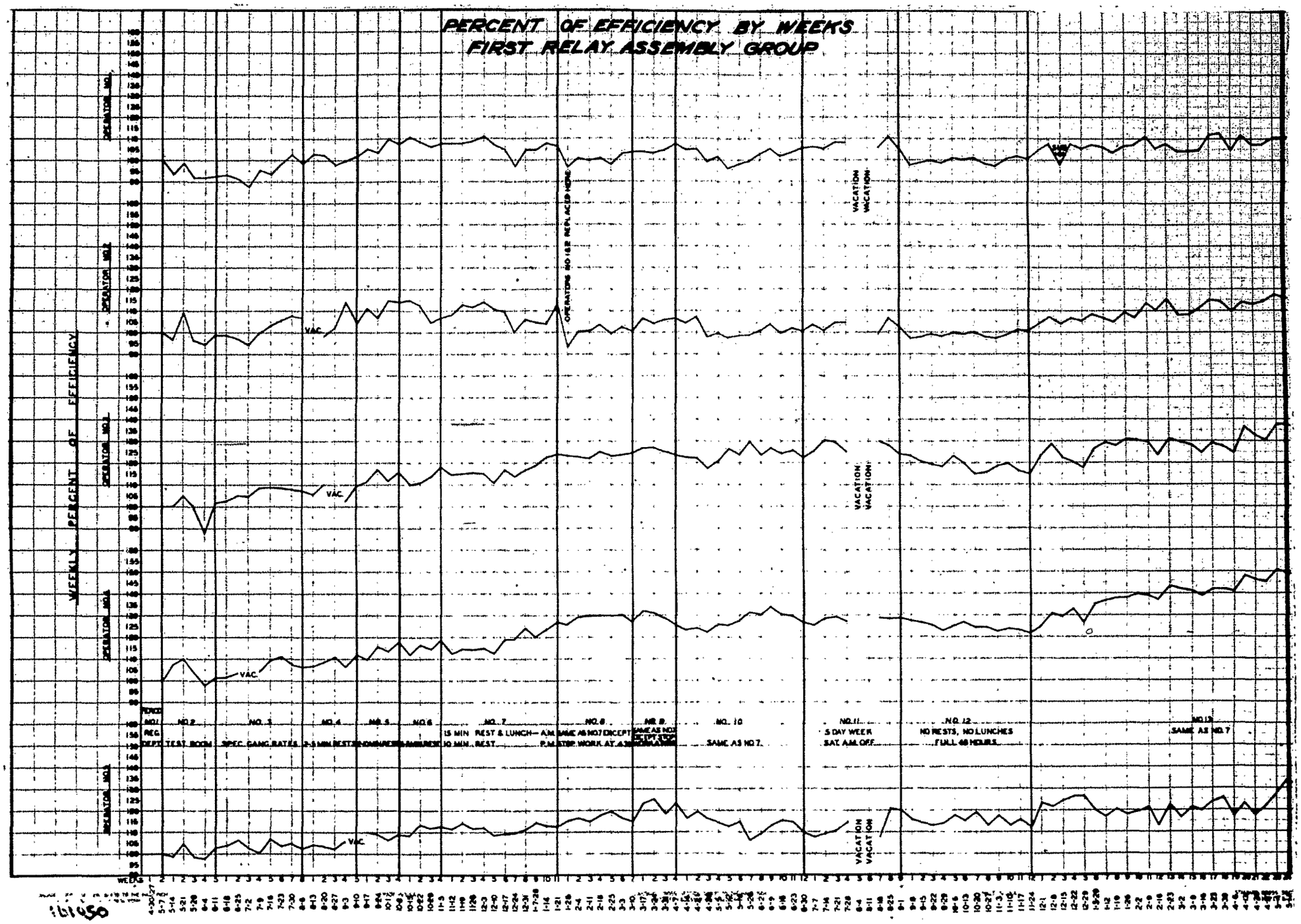
TABLE 1-A
FIRST RELAY ASSEMBLY GROUP

Table Showing Division of Data of Table 1 Due to Replacing of Operators Nos. 1 and 2 at the Beginning of Period No. 8

Period	Hrs. of Work per Wk.	No. of Wk. in Period	Second Operators Nos. 1 and 2 Average Hourly Output	Second Operators Nos. 1 and 2 Average Per Cent of Efficiency	Operators Nos. 3, 4, and 5 Average Hourly Output	Operators Nos. 3, 4, and 5 Average Per Cent of Efficiency
No. 8	43.17	1	60.3	95.2	60.0	121.8
15 Min. A.M. Lunch,		2	63.9	100.3	60.6	123.1
10 Min. P.M. Rest,		3	63.5	99.8	59.6	121.0
4:30 Stop		4	64.8	101.7	61.2	124.3
		5	63.3	99.4	62.1	126.1
		6	65.1	102.3	61.0	123.8
		7	65.0	102.1	60.5	122.8
			63.7	100.0	60.7	123.3
No. 9	40.67	1	66.7	104.7	62.6	127.1
15 Min. A.M. Lunch,		2	65.8	103.3	63.1	128.2
10 Min. P.M. Rest,		3	66.7	104.7	61.2	124.4
4:00 Stop		4	67.9	106.7	61.2	124.3
			66.8	104.9	62.0	126.0
No. 10	45.67	1	66.1	103.8	59.6	121.1
15 Min. A.M. Lunch,		2	68.4	107.4	60.2	122.2
10 Min. P.M. Rest		3	62.6	98.3	58.5	118.8
Same as No. 7		4	63.7	100.0	59.4	120.6
		5	61.5	96.6	60.2	122.2
		6	62.3	97.9	60.1	122.0
		7	62.8	98.7	60.4	122.6
		8	64.8	101.7	59.7	121.1
		9	66.5	104.4	61.6	125.1
		10	64.2	100.8	61.1	124.0
		11	65.3	102.6	60.8	123.4
		12	65.0	102.0	58.9	119.7
			64.4	101.2	60.0	121.9

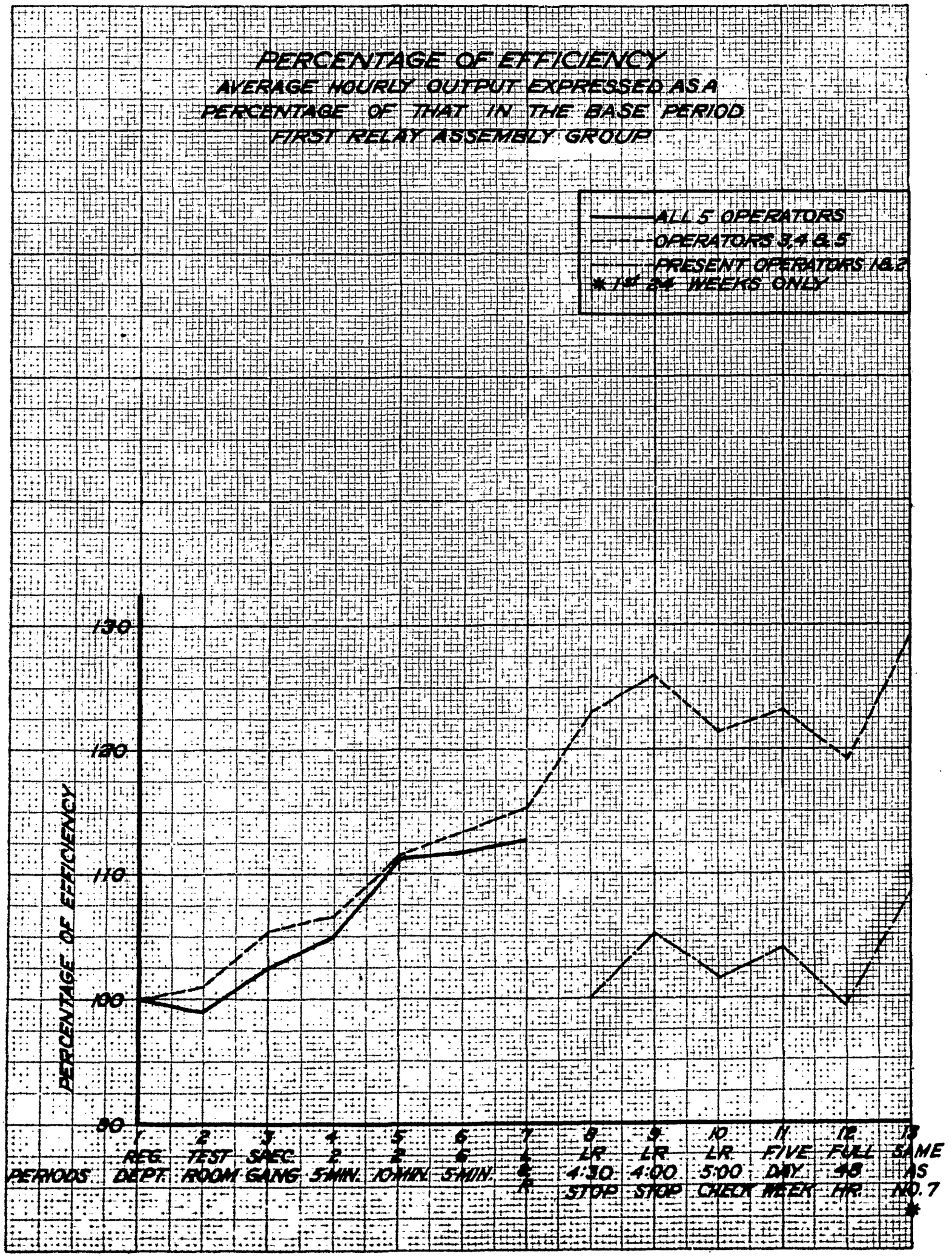
Period	Hrs. of Work per Wk.	No. of Wk. in Period	Second Operators Nos. 1 and 2 Average Hourly Output	Second Operators Nos. 1 and 2 Average Per Cent of Efficiency	Operators Nos. 3, 4, and 5 Average Hourly Output	Operators Nos. 3, 4, and 5 Average Per Cent of Efficiency
No. 11	41.67	1	65.9	103.5	58.8	119.5
15 Min. A.M. Lunch,		2	65.2	102.4	60.6	122.8
10 Min. P.M. Rest,		3	66.9	105.1	60.8	123.3
Saturday A.M. off		4	67.0	105.2	60.4	122.7
		5	Vac.	-	Vac.	-
		6	Vac.	-	Vac.	-
		7	63.6	99.9	60.2	122.0
		8	68.3	107.2	62.1	126.1
		9	65.4	102.8	61.3	124.5
			66.0	103.7	60.6	123.0
No. 12	48.00	1	61.9	97.3	60.5	122.8
No Lunches, No Rests		2	62.3	97.9	59.6	120.9
Same as No. 3		3	63.3	99.4	59.1	119.9
		4	62.7	98.4	58.5	118.8
		5	63.7	100.2	60.2	121.9
		6	63.5	99.8	59.7	120.9
		7	63.9	100.5	58.9	119.2
		8	62.6	98.4	58.2	117.8
		9	61.9	97.3	59.1	119.6
		10	63.4	99.7	58.6	118.6
		11	64.6	101.6	58.4	118.2
		12	64.2	100.9	57.4	116.2
			63.2	99.4	59.0	119.4
No. 13	45.67	1	66.4	104.4	61.1	123.7
15 Min. A.M. Lunch, 10 Min. P.M. Rest. Operators furnish Lunch. Company furnishes beverage.		2	68.3	107.4	62.8	127.1
		3	64.5	101.4	62.0	125.5
		4	67.9	106.8	62.5	126.5

Period	Hrs. of Work per Wk.	No. of Wk. in Period	Second Operators Nos. 1 and 2		Operators Nos. 3, 4, and 5	
			Average Hourly Output	Average Per Cent of Efficiency	Average Hourly Output	Average Per Cent of Efficiency
No. 13 Cont'd	45.67	5	67.1	105.5	60.9	123.3
		6	68.4	107.5	62.7	126.9
		7	67.7	106.4	63.2	127.9
		8	66.4	104.4	63.5	128.5
		9	68.5	107.7	63.7	128.9
		10	67.9	106.8	64.2	130.0
		11	71.5	112.4	64.2	130.0
		12	68.7	108.0	61.5	124.5
		13	70.8	111.3	65.3	132.2
		14	67.4	106.0	63.9	129.4
		15	67.5	106.1	64.3	130.2
		16	68.7	108.0	63.1	127.7
		17	72.1	113.4	64.8	131.2
		18	72.1	113.4	65.0	131.5
		19	68.2	107.2	63.1	127.7
		20	71.8	112.9	67.2	136.0
		21	70.2	110.3	65.4	132.4
		22	70.3	110.5	65.4	132.4
		23	72.4	113.8	68.3	138.3
		24	72.3	113.7	69.3	140.3



32.

UNIVERSITY OF WISCONSIN - MILWAUKEE



UNIVERSITY OF WISCONSIN - MILWAUKEE

TABLE

FIRST RELAY ASSEMBLY GROUP

Average Hourly Output Expressed as a Percentage of the Operator's Maximum Speed

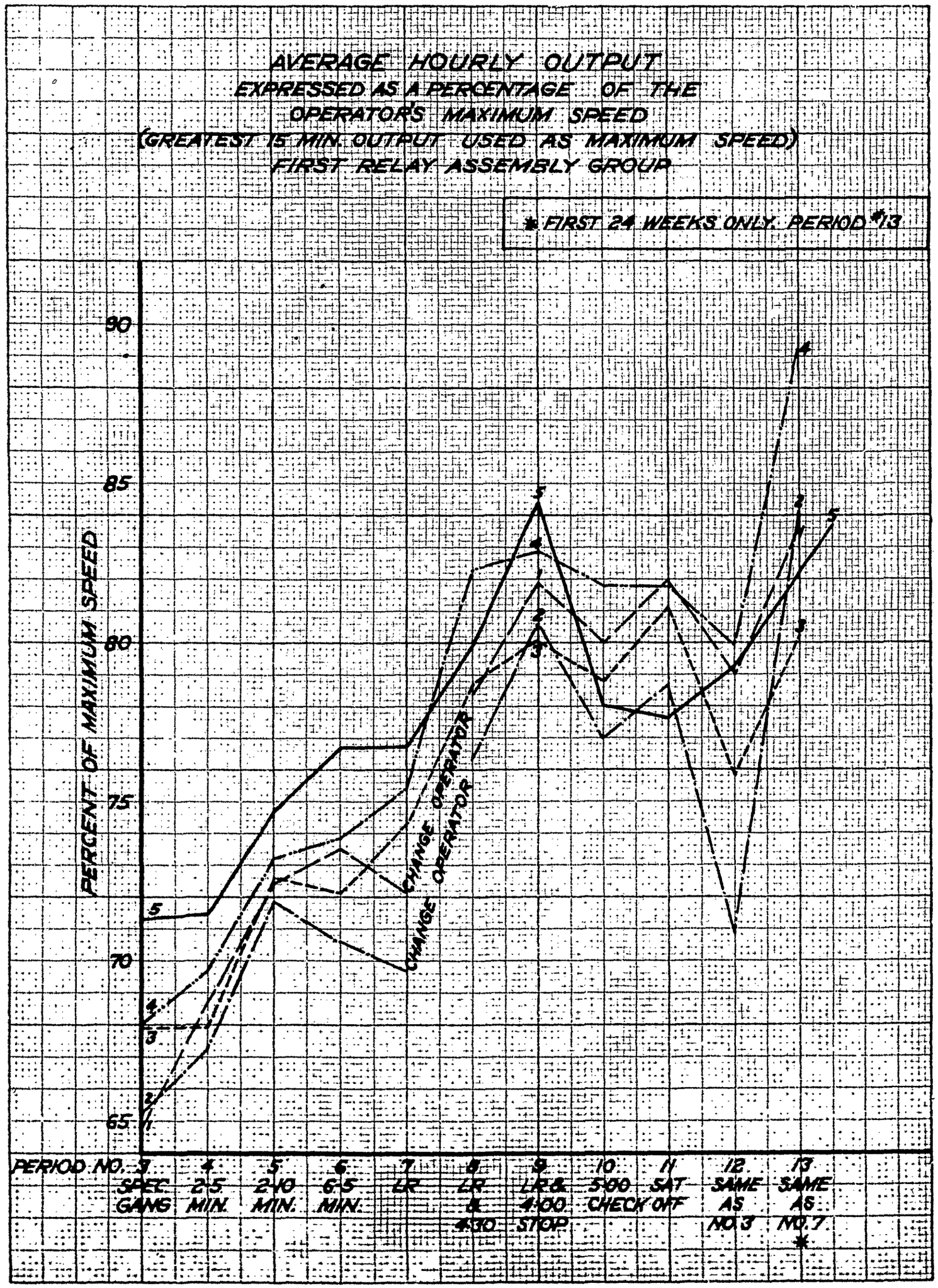
(Greatest 15 Minute Output During the First Year in the Test Room Used as Maximum Speed)

Period	Operators 1	2	3	4	5
No. 3 - Special Gang Rate	64.7	65.2	67.9	68.0	71.3
No. 4 - Two 5 Min. Rests	68.7	67.2	67.9	69.7	71.5
No. 5 - Two 10 Min. Rests	72.4	71.8	72.6	73.2	74.7
No. 6 - Six 5 Min. Rests	73.5	70.6	72.1	73.8	76.7
No. 7 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest	72.1	69.7	74.3	75.4	76.7
*No. 8 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:30 Stop	78.4	76.3	78.7	82.3	79.9
No. 9 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:00 Stop	81.9	80.6	80.1	82.9	84.3
No. 10 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest	80.0	77.0	78.8	81.8	78.0
No. 11 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, Saturday A.M. off	82.0	78.7	81.1	81.8	77.6
No. 12 - No Lunches, No Rests	78.0	70.9	75.8	79.8	79.2
No. 13 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest. Operators furnish Lunch. Company furnishes beverage.	83.7	84.1	80.2	89.2	83.7

*Operators Nos. 1 & 2 replaced at beginning of this period.

AVERAGE HOURLY OUTPUT
EXPRESSED AS A PERCENTAGE OF THE OPERATOR'S MAXIMUM SPEED
(GREATEST 15 MIN. OUTPUT USED AS MAXIMUM SPEED)
FIRST RELAY ASSEMBLY GROUP

* FIRST 24 WEEKS ONLY. PERIOD #13



3. Weekly Output

Table 3 and the "Total Weekly Output" graphs which follow indicate the outputs for individual operators and for the group as a whole throughout the periods of the study. It will be seen that there has been a general upward trend in production. The tables of the rate of production show that the hourly output increased with the shortening of the working day by rest pauses and the early stop conditions. It will be noted from the weekly output graphs that the four o'clock stop and the five day week took off so much working time that the total weekly output fell somewhat. The total output, however, remained well above the base rate. Following the weekly output graphs is an average daily output graph arranged by periods for comparison. All rest pauses were more than compensated for by the increased rate of output. In period No. 12 the operators returned to the full working day without any rest pauses whatever and the output reached its highest level up to that time; nevertheless, when the twenty-five minutes of rest were restored in period No. 13 the total weekly output still further increased, giving further evidence of the ability of the operator to compensate for the rest pauses by increased speed.

The early periods of the test were not long enough for the production lines to reach plateaus. One cannot determine from them what further changes might have developed if these periods had continued. This is less true for later periods; but even here it will be noticed that, although periods Nos. 7, 10, and 13 involve the same length working day, the upward trend has continued through all three of these periods. Later when this upward trend has ceased it will be possible to remove it from the statistical computations and secure more satisfactory comparisons among the different periods.

TABLE NO. 3
FIRST RELAY ASSEMBLY GROUP
Record of Production in Equivalent to E-901 Relays
Total Weekly Outputs and Average Weekly Output by Periods of Test

Period	Hrs. of Work per Wk.	No. of Wk. in Period	Oper. No. 1 Total Weekly Output	Oper. No. 1 Average Weekly Output	Oper. No. 2 Total Weekly Output	Oper. No. 2 Average Weekly Output	Oper. No. 3 Total Weekly Output	Oper. No. 3 Average Weekly Output	Oper. No. 4 Total Weekly Output	Oper. No. 4 Average Weekly Output	Oper. No. 5 Total Weekly Output	Oper. No. 5 Average Weekly Output	Group Average Weekly Output
No. 1 - Base Period in Regular Department	48.00	1	2422		2463		2374		2374		2294		2385
		2	2426		2309		2400		2394		2338		2373
			4848	2424	4772	2386	4774	2387	4768	2384	4632	2316	
No. 2 - Introduction to Test Room	48.00	1	2284		2187		2411		2539		2305		2345
		2	2410		2616		2525		2592		2440		2517
		3	2270		2204		2400		2438		2299		2322
		4	2241		2193		2097		2309		2289		2226
		5	2266		2345		2446		2397		2404		2371
			11471	2294	11545	2309	11879	2376	12275	2455	11737	2345	
No. 3 - Special Gang Rate	48.00	1	2276		2347		2477		2400		2418		2384
		2	2225		2307		2539		2448		2484		2401
		3	2131		2238		2521		Vac.		2406		2324
		4	2333		2362		2606		2453		2333		2417
		5	2281		2457		2616		2583		2500		2487
		6	2412		2513		2612		2589		2418		2509
		7	2502		2560		2607		2537		2443		2530
		8	2434		2563		2630		2529		2419		2515
			18594	2324	19347	2418	20608	2576	17539	2505	19421	2427	
No. 4 - Two 5 Min. Rests	47.08	1	2491		Vac.		2501		2477		2400		2469
		2	2452		2302		2598		2508		2374		2447
		3	2348		2381		Vac.		2567		2362		2415
		4	2384		2430		2420		2460		2428		2424
		5	2457		2443		2587		2597		Vac.		2521
			12132	2426	9556	2389	10106	2526	12609	2522	9564	2391	

Period	Hrs.of Work per Wk.	No.of Wk.in Period	Oper. No. 1 Total Weekly Output	Oper. No. 1 Average Weekly Output	Oper. No. 2 Total Weekly Output	Oper. No. 2 Average Weekly Output	Oper. No. 3 Total Weekly Output	Oper. No. 3 Average Weekly Output	Oper. No. 4 Total Weekly Output	Oper. No. 4 Average Weekly Output	Oper. No. 5 Total Weekly Output	Oper. No. 5 Average Weekly Output	Group Average Weekly Output
No. 5 - Two 10	46.17	1	2501		2602		2587		2510		2501		2540
Min. Rests		2	2438		2449		2710		2628		2455		2536
		3	2577		2621		2588		2578		2394		2552
		4	2478		2569		2630		2634		2427		2548
			9994	2498	10241	2560	10515	2629	10356	2588	9777	2444	
No. 6 - Six 5	46.17	1	2547		2580		2498		2493		2390		2502
Min. Rests		2	2487		2522		2510		2595		2501		2523
		3	2458		2371		2582		2553		2477		2488
		4	2491		2434		2693		2645		2510		2555
			9983	2496	9907	2477	10283	2571	10286	2571	9878	2469	
No. 7 - 15 Min.	45.67	1	2519		2506		2623		2532		2480		2532
A.M. Lunch, 10		2	2508		2558		2641		2576		2537		2564
Min. P.M. Rest		3	2516*		2528		2740		2569		2484		2567
		4	2575*		2585		2641		2584		2493		2576
		5	2496		2520		2544		2505		2438		2501
		6	2435		2418		2675		2676		2301		2501
		7	2256		2271		2607		2675		2429		2448
		8	2437		2404		2683		2799		2463		2557
		9	2433		2386		2726		2702		2558		2561
		10	2510		2371		2822		2760		2529		2598
		11	2491		2573		2861		2856		2510		2658
			27176	2470	27120	2465	29563	2688	29334	2658	27222	2475	

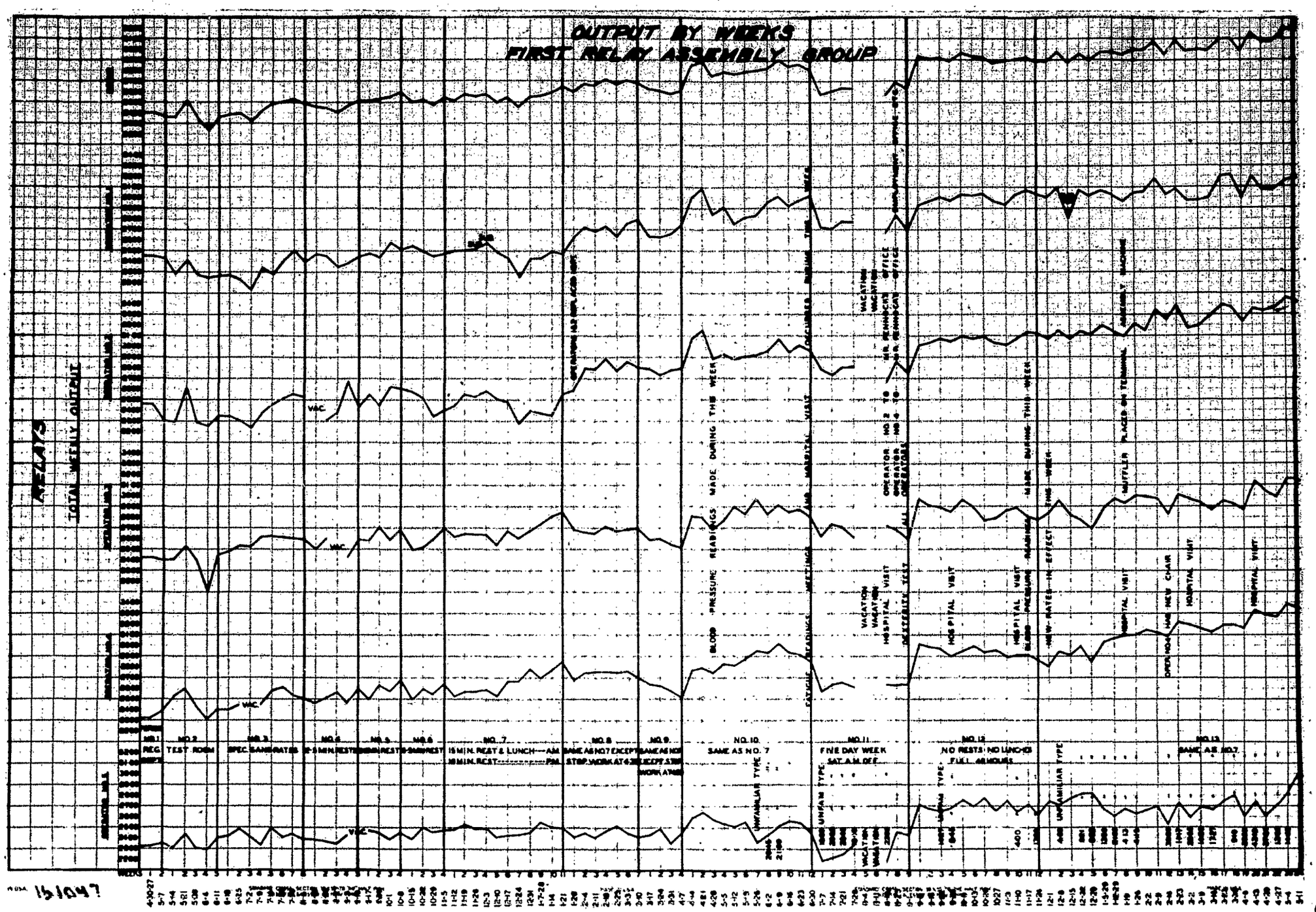
*Substitution of operator.

Period	Hrs. of Work per Wk.	No. of Wk. in Period	Oper. No. 1 Total Weekly Output	Oper. No. 1 Average Weekly Output	Oper. No. 2 Total Weekly Output	Oper. No. 2 Average Weekly Output	Oper. No. 3 Total Weekly Output	Oper. No. 3 Average Weekly Output	Oper. No. 4 Total Weekly Output	Oper. No. 4 Average Weekly Output	Oper. No. 5 Total Weekly Output	Oper. No. 5 Average Weekly Output	Group Average Weekly Output
**No. 8 - Same as No. 7, but 4:30 Stop	43.17	1	2622		2584		2681		2676		2416		2599
		2	2721		2795		2658		2743		2453		2674
		3	2694		2787		2607		2700		2412		2640
		4	2712		2880		2707		2746		2475		2705
		5	2675		2784		2753		2748		2539		2699
		6	2761		2859		2685		2762		2446		2703
		7	2798		**2812		2703		2704		2425		2688
			18983	2712	19501	2786	18794	2685	19079	2726	17166	2452	
No. 9 - Same as No. 7, but 4:00 stop	40.67	1	2634		2788		2591		2641		2403		2611
		2	2624		2726		2594		2625		2482		2610
		3	2655		2770		2555		2574		2344		2579
		4	2739		2785		2516		2504		2418		2598
			10652	2663	11069	2767	10256	2564	10344	2586	9677	2419	
No. 10 - Same as No. 7 (Check)	45.67	1	2984		3053		2814		2773		2585		2842
		2	3094		3150		2804		2791		2647		2897
		3	2839		2873		2686		2751		2580		2746
		4	2901		2912		2763		2832		2543		2790
		5	2747		2875		2924		2817		2508		2774
		6	2801		2894		2830		2864		2543		2786
		7	2833		2906		2973		2949		2357		2804
		8	2951		2965		2825		2930		2423		2819
		9	3008		3064		2904		3009		2514		2899
		10	2919		2940		2847		2930		2561		2839
		11	2964		3002		2877		2917		2549		2862
		12	2994		2948		2794		2835		2434		2801
			35035	2920	35582	2965	34041	2837	34398	2866	30224	2519	

**Operators Nos. 1 & 2 replaced at the beginning of this period.

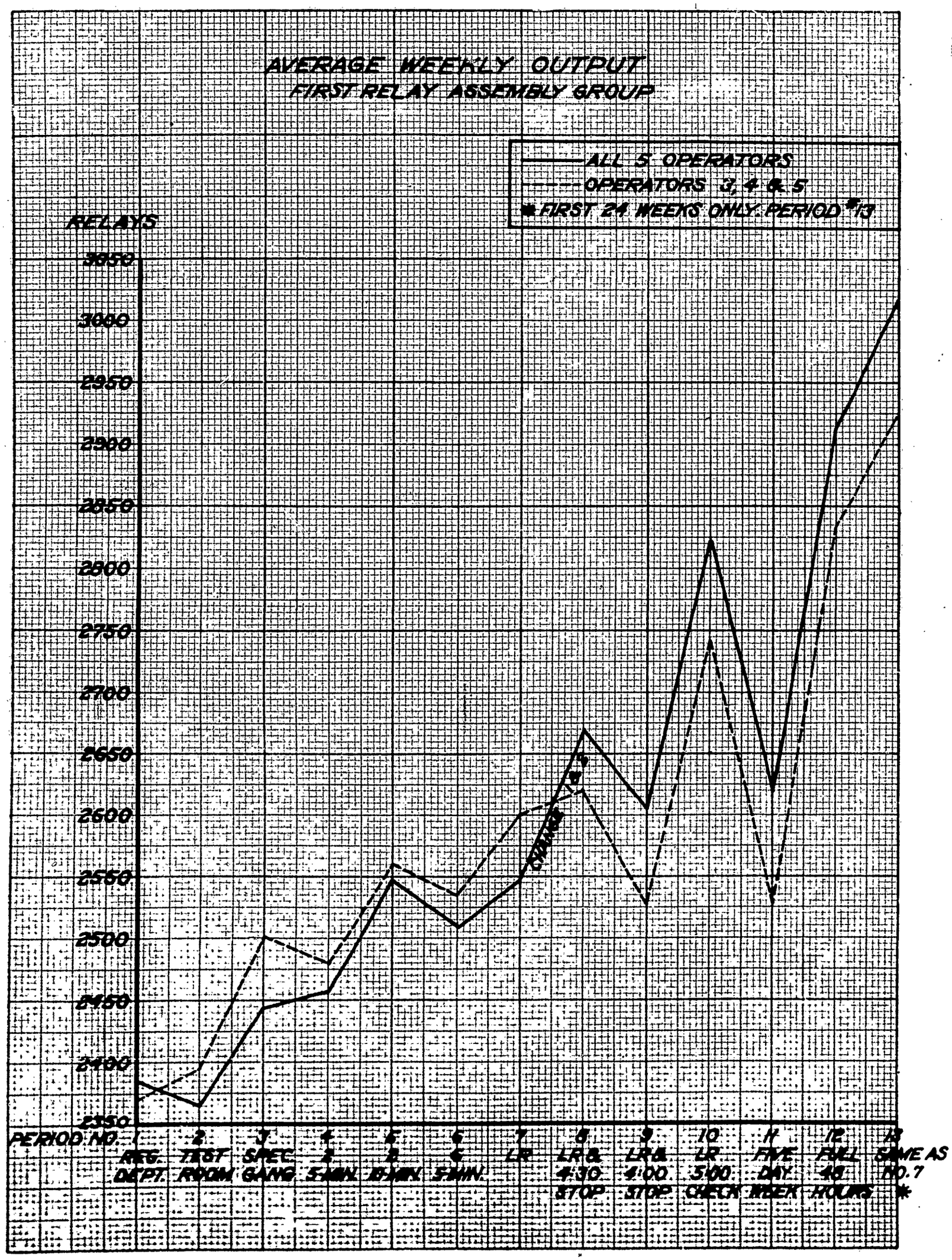
Period	Hrs. of Work per Wk.	No. of Wk. in Period	Oper. No. 1 Total Weekly Output	Oper. No. 1 Average Weekly Output	Oper. No. 2 Total Weekly Output	Oper. No. 2 Average Weekly Output	Oper. No. 3 Total Weekly Output	Oper. No. 3 Average Weekly Output	Oper. No. 4 Total Weekly Output	Oper. No. 4 Average Weekly Output	Oper. No. 5 Total Weekly Output	Oper. No. 5 Average Weekly Output	Group Average Weekly Output
No. 11 - Same as No. 7, but Saturday A.M. off	41.67	1	2711		2776		2611		2571		2181		2570
		2	2697		2732		2726		2636		2217		2602
		3	2772		2804		2709		2646		2248		2636
		4	2769		2813		2615		2608		2335		2628
		5	Vacation		Vacation		Vacation		Vacation		Vacation		Vac.
		6	Vacation		Vacation		Vacation		Vacation		Vacation		Vac.
		7	2656		2647		2714		2628		2183		2566
		8	2835		2857		2683		2629		2455		2692
		9	2696		2754		2596		2636		2435		2623
			19136	2734	19383	2769	18654	2667	18354	2622	16054	2294	
No. 12 - Same as No. 3 (No Lunches or Rests)	48.00	1	2933		3011		2983		3008		2712		2929
		2	2962		3023		2914		2991		2676		2913
		3	3004		3067		2887		2971		2648		2915
		4	2971		3043		2853		2902		2674		2889
		5	3023		3089		2968		2952		2752		2957
		6	3020		3072		2898		2994		2697		2936
		7	3036		3094		2771		2937		2779		2923
		8	2967		3037		2786		2943		2649		2876
		9	2928		3015		2862		2897		2752		2891
		10	3020		3062		2884		2908		2648		2904
		11	3066		3129		2800		2907		2708		2922
		12	3034		3124		2768		2874		2620		2884
			35964	2997	36766	3064	34374	2865	35284	2940	32315	2693	

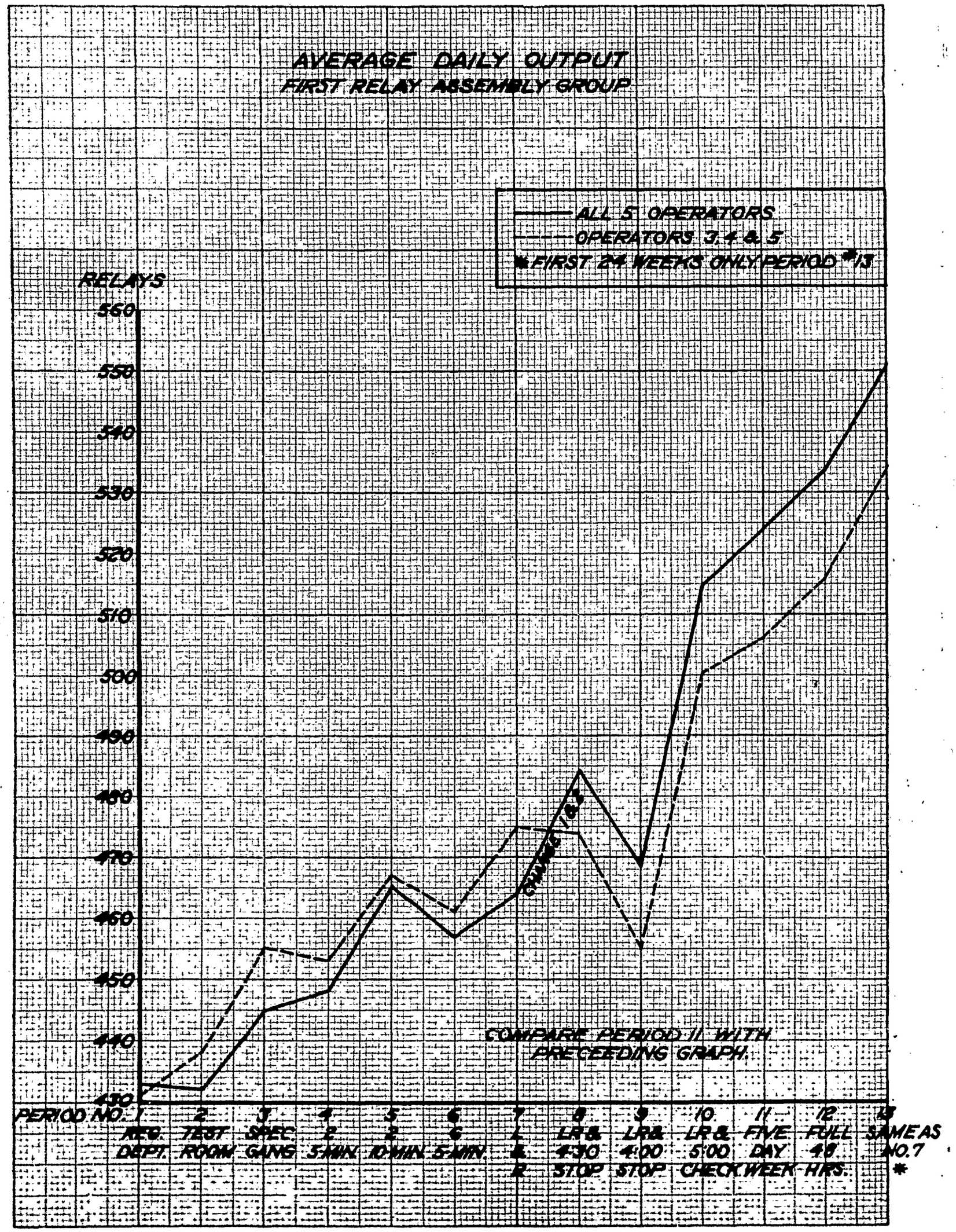
Period	Hrs. of Work per Wk.	No. of Wk. in Period	Oper. No. 1 Total Weekly Output	Oper. No. 1 Average Weekly Output	Oper. No. 2 Total Weekly Output	Oper. No. 2 Average Weekly Output	Oper. No. 3 Total Weekly Output	Oper. No. 3 Average Weekly Output	Oper. No. 4 Total Weekly Output	Oper. No. 4 Average Weekly Output	Oper. No. 5 Total Weekly Output	Oper. No. 5 Average Weekly Output	Group Average Weekly Output
No. 13 - Same as No. 7, but operators furnish own Lunches. Company furnishes beverages.	45.67	1	3000	3063	2820	2803	2743	2887					
		2	3089	3152	2955	2942	2713	2971					
		3	2814	3072	2809	2915	2774	2877					
		4	3065	3138	2765	2992	2807	2954					
		5	3017	3107	2691	2845	2812	2894					
		6	3062	3188	2891	3033	2665	2698					
		7	3036	3140	2974	3073	2606	2966					
		8	2969	3092	2932	3093	2676	2952					
		9	3042	3210	2997	3101	2629	2996					
		10	3056	3144	2991	3143	2659	2997					
		11	3180	3348	2977	3125	2698	3067					
		12	3030	3247	2822	3083	2521	2941					
		13	3077	3382	3004	3220	2724	3081					
		14	2976	3173	2973	3194	2592	2983					
		15	2978	3188	2941	3173	2693	2995					
		16	2996	3280	2860	3122	2667	2985					
		17	3201	3382	2952	3183	2748	3093					
		18	3211	3377	2926	3189	2793	3107					
		19	2993	3239	2864	3175	2608	2976					
		20	3199	3358	3132	3328	2743	3153					
		21	3070	3339	3043	3298	2618	3073					
		22	3065	3357	2983	3276	2706	3077					
		23	3157	3453	3158	3382	2822	3195					
		24	3173	3427	3157	3353	3005	3173					



79a

UNIVERSITY OF WISCONSIN - MILWAUKEE


AVERAGE WEEKLY OUTPUT
FIRST RELAY ASSEMBLY GROUP
ALL 5 OPERATORS
OPERATORS 3, 4 & 5
* FIRST 24 WEEKS ONLY: PERIOD #13
RELAYS
3050
3000
2950
2900
2850
2800
2750
2700
2650
2600
2550
2500
2450
2400
2350
PERIOD NO.
1 REG. DEPT.
2 TEST ROOM
3 SPEC. GANG
4 2 SMIN.
5 2 BMIN.
6 5 MIN.
7 LR
8 LR & 4:30 STOP
9 LR & 4:00 STOP
10 LR 3:00 CHECK
11 FIVE DAY WEEK
12 FULL 40 HOURS
13 SAME AS NO. 7 *



UNIVERSITY OF WISCONSIN - MILWAUKEE

4. The Significance and Reliability of Variations in Output.

The reliability of changes in the average daily output under the different periods of work varies directly with the number of output readings secured and inversely with the fluctuation in output from day to day. The output data shown indicate an increasing production which is obviously so great as to be statistically significant and by no possibility due to accidental variations in output. The hourly rate of production has increased with the shortening of the working day. Direct reference to Table No. 3 shows that the actual output has increased in spite of the shorter hours. One naturally asks, however, whether these increases in output from period to period have real statistical significance or whether they are within the range of chance variation.

The usual statistical procedure has been followed in determining the reliability of these comparative output figures in different periods. The difference between the average daily output for each period of work following the base period and the average daily output of the base period is compared with the probable error of that difference. A similar comparison is made between each period of work following the "special gang rate" period and this period.

It will be seen that there was no significant difference between the output of these operators in the regular department and their output in the test room during period No. 2 while they were being paid on the same basis and while they were getting used to the new working conditions. For all of the features of work following period No. 2, however, the actual average hourly output per week has been significantly greater than in the old department. This is true even when the working day has been shortened by one hour and twenty-five minutes during the period involving four o'clock stop. Production during the five day week was practically the same as that for the four o'clock stop.

The following pages illustrate the statistical procedure, and Table No. 4 presents the results of the computations.

Consider the daily output data for period No. 1. A daily average is computed by dividing the equivalent total number of relays produced in the period by the number of days in the period. The probable error, P.E., that is, the expected chance fluctuation of the average (as compared with the average for another group of persons taken from the same main group) is computed by taking 0.674 times the square root of the sum of the squares of the individual differences between the average and each day's output, and dividing this product by the number of days in the period, or -

$$\frac{0.674\sqrt{\text{sum of squares of individual differences from average}}}{\text{number of days in period}}$$

The probable error for period No. 2 is computed in the same fashion. The probable error in the difference between the averages for the two periods is the square root of the sum of the squares of the individual probable errors.

Now it is desired to know whether the difference between the averages for the two periods is significant, that is, whether it is more than a mere chance difference. The criterion for this is based upon the magnitude of the quotient obtained by dividing the difference between the averages by the probable error of the difference,

or - $$\frac{\text{difference between averages}}{\text{probable error of difference}}$$

When this ratio is equal to one there is an even chance that the difference between the averages is purely accidental. When the ratio equals four there are 99.7 chances in 100 that the difference is significant. When the ratio is four or more, complete statistical reliability is assured.

SAMPLE SHEET SHOWING METHOD USED IN THE DETERMINATION OF THE RELIABILITY OF COMPARATIVE AVERAGE OUTPUTS

Average Daily Output for All Five Operators
Period No. 1
Base Period in Regular Department

Relays	Diff.	Diff.^{2}
441	8	64
447	14	196
442	9	81
446	13	169
425	8	64
406	27	729
438	5	25
434	1	1
447	14	196
425	8	64
425	8	64
421	12	144
432	1	1
13/5629		1798
433		

$$\sqrt{1798} = 42.4$$

$$(P.E.)_1 = \frac{.674 \times 42.4}{13} = 2.20$$

Average Daily Output for All Five Operators
Period No. 2
Introduction to Test Room

Relays	Diff.	Diff.^{2}
424	8	64
445	13	169
433	1	1
451	19	361
463	31	961
471	39	1521
469	37	1369
455	23	529
451	19	361
430	2	4
427	5	25
438	6	36
432	0	0
427	5	25
420	12	144
412	20	400
409	23	529
395	37	1369
401	31	961
407	25	625
418	14	196
431	1	1
425	7	49
434	2	4
434	2	4
439	7	49
437	5	25
418	14	196
28/12096		9978
432		

$$\sqrt{9978} = 99.9$$

$$(P.E.)_2 = \frac{0.674 \times 99.9}{28} = 2.40$$

$$\frac{\text{Diff. between averages}}{\sqrt{(P.E.)_1^2 + (P.E.)_2^2}}$$

$$= \frac{432 - 433}{\sqrt{(2.20)^2 + (2.40)^2}}$$

$$= \frac{-1}{3.26}$$

$$= -0.31$$

TABLE NO. 4
RELIABILITY OF COMPARATIVE AVERAGE OUTPUTS
ALL FIVE OPERATORS

Period	Average Daily Output	% of Base Rate	P.E. of Average	Later Periods Compared with Output in Regular Department: Periods Compared	Diff. of Averages	P.E.of Diff.	Diff. P.E.Diff.	Later Periods Compared with Output in Special Gang Rate Period: Periods Compared	Diff. of Averages	P.E.of Diff.	Diff. P.E.Diff.
No. 1 - Base Period in Regular Department.	433	100	2.20								
No. 2 - Introduction to Test Room	432	99.8	2.40	No. 1 vs. No. 2	-1	3.26	.31				
No. 3 - Special Gang Rate	445	102.8	1.63	No. 1 vs. No. 3	12	2.74	4.38				
No. 4 - Two 5 Minute Rests	448	103.5	1.60	No. 1 vs. No. 4	15	2.72	5.51	No. 3 vs. No. 4	3	2.28	1.32
No. 5 - Two 10 Minute Rests	465	107.4	1.93	No. 1 vs. No. 5	32	2.93	10.91	No. 3 vs. No. 5	20	2.53	7.90
No. 6 - Six 5 Minute Rests	457	105.5	1.98	No. 1 vs. No. 6	24	2.96	8.11	No. 3 vs. No. 6	12	2.56	4.69
No. 7 - 15 Minute A.M. Lunch, 10 Minute P.M. Rest	464	107.1	1.19	No. 1 vs. No. 7	31	2.50	12.40	No. 3 vs. No. 7	19	2.02	9.40
No. 8 - Same as No. 7, but 4:30 Stop	484	111.8	1.07	No. 1 vs. No. 8	51	2.45	20.80	No. 3 vs. No. 8	39	1.95	20.00
No. 9 - Same as No. 7, but 4:00 Stop	469	108.3	1.16	No. 1 vs. No. 9	36	2.49	14.48	No. 3 vs. No. 9	24	2.00	12.00

Period	Average Daily Output	% of Base Rate	P.E. of Average	Later Periods Compared with Output in Regular Department: Periods Compared	Diff. of Averages	P.E. of Diff.	Diff. / P.E.Diff.	Later Periods Compared with Output in Special Gang Rate Period: Periods Compared	Diff. of Averages	P.E. of Diff.	Diff. / P.E.Diff.
No. 10 - Same as No. 7 (Check)	515	118.9	.98	No. 1 vs. No. 10	82	2.41	34.00	No. 3 vs. No. 10	70	1.90	36.80
No. 11 - Same as No. 7 but Sat. A.M. off	528	122.3	1.50	No. 1 vs. No. 11	95	2.66	35.7	No. 3 vs. No. 11	83	2.21	37.5
No. 12 - Same as No. 3, no rests or lunch	534	123.4	1.07	No. 1 vs. No. 12	101	2.45	41.2	No. 3 vs. No. 12	89	1.95	45.7

TABLE NO. 4A
RELIABILITY OF COMPARATIVE AVERAGE OUTPUTS
OPERATORS NOS. 3, 4, AND 5 ONLY

Period	Average Daily Output	% of Base Rate	P.E.of Average	Later Periods Compared with Output in Regular Department: Periods Compared	Diff. of Averages	P.E.of Diff.	Diff. / P.E.Diff.	Later Periods Compared with Output in Special Gang Rate Period: Periods Compared	Diff. of Averages	P.E.of Diff.	Diff. / P.E.Diff.
No. 1 - Base Period in Regular Department	431	100	2.15								
No. 2 - Introduction to Test Room	438	101.6	2.71	No. 1 vs. No. 2	7	3.46	2.02				
No. 3 - Special Gang Rate	455	105.6	1.12	No. 1 vs. No. 3	24	2.42	9.92				
No. 4 - Two 5 Minute Rests	453	105.1	1.73	No. 1 vs. No. 4	22	2.76	7.97	No. 3 vs. No. 4	-2	2.06	.97
No. 5 - Two 10 Minute Rests	467	108.4	2.11	No. 1 vs. No. 5	36	3.01	11.98	No. 3 vs. No. 5	12	2.39	5.02
No. 6 - Six 5 Minute Rests	461	107.0	2.54	No. 1 vs. No. 6	30	3.33	9.01	No. 3 vs. No. 6	6	2.78	2.16
No. 7 - 15 Minutes A.M. Lunch, 10 Minute P.M. Rest	475	110.2	1.45	No. 1 vs. No. 7	44	2.59	17.00	No. 3 vs. No. 7	20	1.83	10.92
No. 8 - Same as No. 7, but 4:30 Stop	474	110.0	1.14	No. 1 vs. No. 8	43	2.43	17.70	No. 3 vs. No. 8	19	1.60	11.90
No. 9 - Same as No. 7, but 4:00 Stop	455	105.6	1.60	No. 1 vs. No. 9	24	2.68	9.02	No. 3 vs. No. 9	0	1.95	0
No. 10 - Same as No. 7 (Check)	500	116.0	.90	No. 1 vs. No. 10	69	2.33	29.60	No. 3 vs. No. 10	45	1.44	31.20

Period	Average Daily Output	% of Base Rate	P.E.of Average	Later Periods Compared with Output in Regular Department: Periods Compared	Diff. of Averages	P.E.of Diff.	Diff. P.E.Diff.	Later Periods Compared with Output in Special Gang Rate Period: Periods Compared	Diff. of Averages	P.E.of Diff.	Diff. P.E.Diff.
No. 11 - Same as No. 7 but Sat. A.M. off	508	118.1	1.56	No. 1 vs. No. 11	77	2.66	29.0	No. 3 vs. No. 11	53	1.92	27.6
No. 12 - Same as No. 3 - No lunch or Rest	517	120.1	1.33	No. 1 vs. No. 12	86	2.52	34.1	No. 3 vs. No. 12	62	1.74	35.6

5. Speed Tests.

On August 30, 1928, the five girls in the special testing room working on the assembling of relays were given the pegboard and finger-dexterity tests. Their scores are shown below. In column 1 for each test is shown the absolute score, and in column 2 is shown the percentage of 117 other assemblers and bench hands with two or more years of service who made the same score or less:

Oper. No.	Name	Pegboard Test* (1) No. Pegs	(2) Rel. Score	G. E. Finger-Dexterity Test** Dominant Hand (1) Time	(2) Rel. Score	Minor Hand (1) Time	(2) Rel. Score
2	[redacted]	20	97	5.35'	99	6.57'	85
1	[redacted]	19	93	(L)6.25'	61	(R)6.80'	75
4	[redacted]	17	73	6.06'	81	7.12'	53
3	[redacted]	19	93	6.87'	50	7.28'	38
5	[redacted]	13	26	7.42'	10	8.82'	36

It will be noticed that the scores for the first four girls tend to be in the upper 50% of the scores for other girls on similar work, while the scores for the fifth girl are all in the lower 50%.

No. 5 ([redacted]) actually does 90% as much work as No. 2 [redacted]) although in speed test she did only 65% as much. This fact suggests that [redacted] makes up for lack of speed by a greater consistency of output, and it will be shown later (by the variation data) that this is the case.

* This consists of picking up small pegs and placing one in each hole of the board. The score is based on the number of pegs placed within a time limit.

** This consists of picking up small pegs and placing three in each hole of the board. The score is expressed as the number of minutes required to place a definite number of pegs.

B. VARIATION IN OUTPUT DURING THE DIFFERENT DAYS OF THE WEEK.

It was believed that further light would be shed upon working efficiency by a study of output on different days of the week. Each operator shows appreciable variation in output from day to day. This is seen by reference to the basic data table. Wide variation also appears in the shape of the curves showing comparative output by days of the week for each operator when one type of working period is compared with another. Such a daily variation curve for operator No. 5 is included herewith (D V 1). Note particularly that although period No. 7 is like period No. 10 in the arrangement of the working day the shape of the curve for these two periods is decidedly different.

The second graph (D V 2) shows the average output by days of the week for all five operators by periods of the experiment. It will be noted again here that although period No. 7 and period No. 10 are alike in hours worked and in rest pauses, the shape of the curves are markedly different. Because of the wide variation shown by each operator, one feels that no one of the curves is extremely significant.

The wide variation between the curves for individual operators covering the same periods is shown in graph D V 3.

One notices that the curve of the grand average for all operators for ten periods (D V 2 and D V 3) is a smoother curve showing a definitely lower production rate on Monday and Saturday and a uniform production rate on Tuesday, Wednesday, Thursday, and Friday, although the production on Wednesday and Thursday is very slightly higher than for Tuesday and Friday. This composite curve shows that when enough data are brought together to eliminate individual variations, production is definitely and consistently lower on Mondays and Saturdays than on the other days of the week, and that the rate of production on Tuesday, Wednesday, Thursday, and Friday is rather constant.

One naturally looks for evidence of a more sustained output during the later days of the week when the day is shortened by rest pauses and early stops. Certainly this reduced number of hours in the working day does not tend to increase the Saturday output because the relative drop in Saturday output for periods Nos. 8 and 9 (having the shortest working day) is as great as for any other period. To be sure, the upward trend in output

continues until Friday for these two periods, but one is inclined to regard this as more accidental than significant when he notices the continued upward trend until Saturday in period No. 4, the high Friday output in period No. 10 (in contrast to the Friday output in period No. 7), and the fact that the grand average shows a Friday output which is not far below the high point for the week. In other words, there is some indication that the shorter working day tends to keep up the output until Friday, but the inconsistency of the curves (note particularly periods Nos. 4, 5, and 6), and the high Friday output in period No. 10 make it difficult to believe that there is a cumulative fatigue which makes a low Friday output inevitable, at least when there is a lunch and rest pause.

One is naturally interested in comparing the output curves for the individual operators to see whether their fluctuation during the different days of the week is related to their physical condition and their efficiency. It will be seen that the present operators Nos. 1 and 2 have the highest output and show a progressive increase in production from Monday until Friday. Health tests show that these girls are in good physical condition. On the other hand the first operator No. 2 ([redacted]) and operator No. 5 have been inferior in physical condition to the other girls on the test. Their output is below that of the other operators (except the first No. 1 operator) and their curves alone show a general decline from the beginning to the end of the week. Operator No. 5 is the only one whose Monday output is consistently higher than that for any other day in the week. The averages for the other operators show Monday output to be distinctly lower than Tuesday output. In the case of these two operators one might feel that the daily output curve shows evidence of cumulative fatigue. In the case of the present operators Nos. 1, 2, 3, and 4 similar curves distinctly indicate the absence of cumulative fatigue. The comparative daily output curves of [redacted] and [redacted] would suggest that there may be a relationship be[redacted] a low status of physical health and declining output during the week although it may be, on the other hand, that the mental state rather than the physical state of the individual was the important factor.

At present one is inclined to conclude that:

1. A study of the output for the different days of the week does not suggest cumulative fatigue.

2. Although there is high variation, the only days which show a marked and consistently lower production are Monday and Saturday.

3. The reduced production on these two days is probably due to mental preoccupation; i.e., to mental rather than physiological status.

The reasoning in arriving at this last tentative conclusion is as follows: Although the low Monday output might be due to practice effect, that on Saturday could not. There is indication that the low Monday output is not a matter of practice because frequently an operator has a Monday output which is greater than that for any other day for the week in question. Furthermore, three of the 35 highest output records for fifteen minute periods occurred on Monday. It would seem, therefore, that it is not lack of manual dexterity arising from the Sunday rest which causes a low Monday output. There is not evidence of cumulative fatigue as the week advances. No other reasonable explanation appears for low Monday and Saturday output except mental preoccupation.

TABLE —

FIGURES FOR CHART D V 1

Period No.	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	436.5	424.0	442.5	421.5	424.5	389.0
2	433.6	430.2	429.0	432.6	422.	413.2
3	450.1	456.8	447.5	445.3	434.9	424.9
4	439.8	433.5	441.5	446.5	445.5	424.0
5	462.0	460.5	437.8	457.5	453.5	429.8
6	460.3	464.0	451.0	458.8	456.8	441.8
7	456.3	454.1	465.1	465.4	451.8	441.8
8	453.1	451.7	440.7	453.1	454.4	430.6
9	448.0	436.3	430.3	450.3	447.3	429.8
10	476.2	464.5	463.6	457.6	459.8	457.

FIGURES FOR CHART D V 2

1	440	441	445	436	425	414
2	431	434	432	435	432	428
3	444	451	453	448	445	444
4	451	453	448	455	455	450
5	468	474	465	474	467	468
6	453	473	467	468	460	450
7	464	467	474	473	469	456
8	477	489	495	495	497	474
9	466	469	476	480	481	462
10	515	518	520	517	523	515
All*	468	474	475	475	474	464

FIGURES FOR CHART D V 3

First 7 - [redacted]	438.2	445.4	446.5	445.2	443.6	436.7
" 7 - [redacted]	453.3	445.5	449.1	453.8	441.2	431.4
" 10 - [redacted]	471.5	482.6	487.2	484.5	486.6	482.6
" 10 - [redacted]	476.0	480.6	486.5	483.2	485.9	477.3
" 7 - [redacted]	455.5	451.8	449.4	452.5	447.7	434.5
8,9, 10 - [redacted]	502.5	514.4	521.1	524.8	527.3	508.6
8,9, 10 - [redacted]	512.6	527.3	531.0	531.1	537.0	525.8
8,9, 10 - [redacted]	486.8	503.1	507.0	502.0	509.5	491.3
8,9, 10 - [redacted]	504.0	503.8	511.9	505.5	510.7	497.1
8,9, 10 - [redacted]	464.3	455.7	450.8	455.0	455.9	444.2
All*	467.9	473.7	475.06	475.14	474.0	464.7

* Average for group for all ten periods worked.

CHART DV,

DAILY OUTPUT BY DAYS OF WEEK FOR OPERATOR 5 FOR 10 PERIODS
FIRST RELAY ASSEMBLY GROUP

RELAYS

REG. DEPT. NO. 1

TEST ROOM NO. 2

SPEC. GANG NO. 3

2 5-MIN. RESTS NO. 4

2 10-MIN. RESTS NO. 5

6 5-MIN. RESTS NO. 6

LUNCH & REST NO. 7

LUNCH, REST & 4:30 STOP NO. 8

LUNCH, REST & 4:00 STOP NO. 9

LUNCH, REST & 5:00 CHECK NO. 10

M T W T F S

UNIVERSITY OF WISCONSIN - MILWAUKEE

CHART DV2

DAILY OUTPUT OF THE FIVE OPERATORS FOR EACH PERIOD
FIRST RELAY ASSEMBLY GROUP

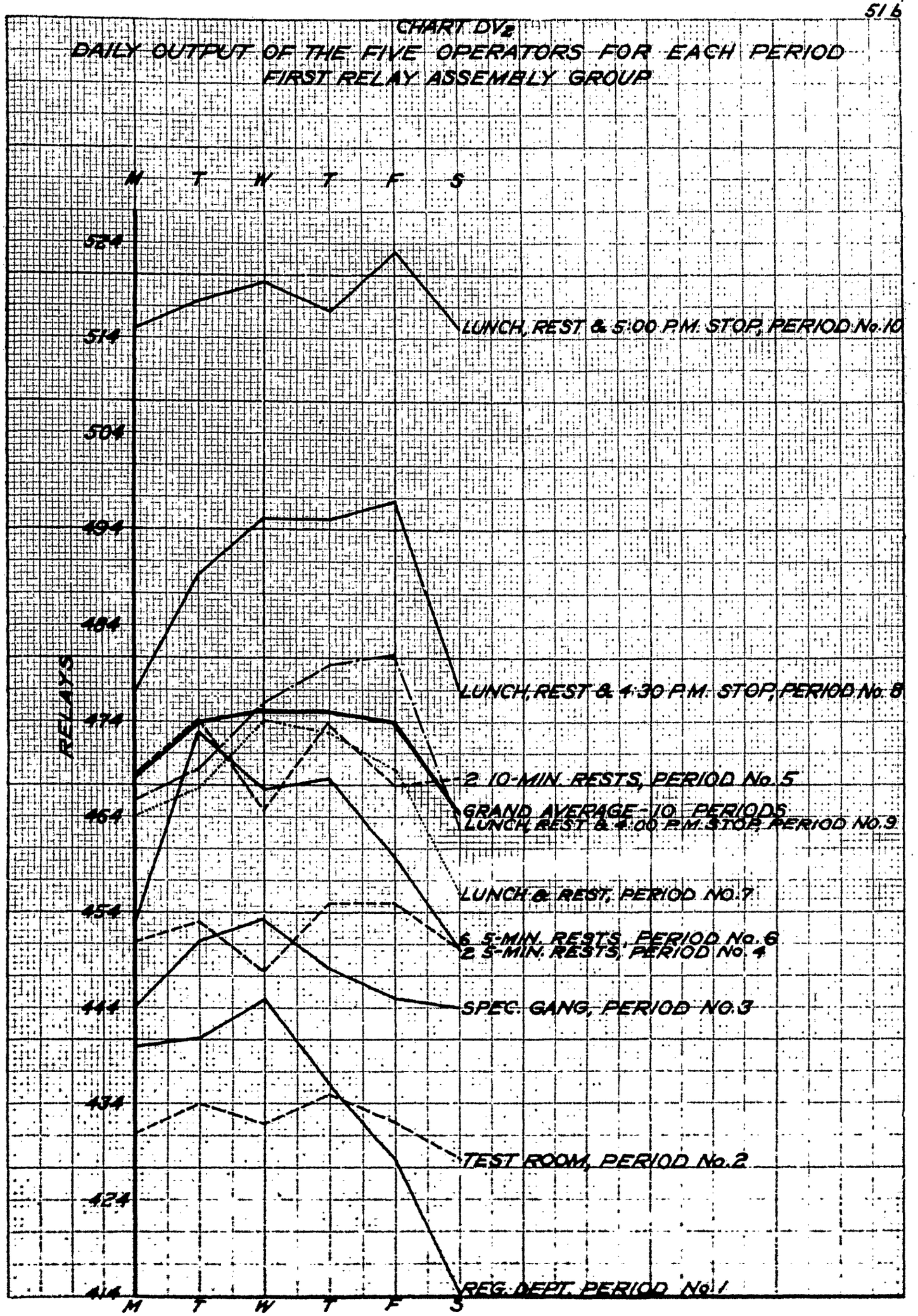


CHART DY3
AVERAGE DAILY OUTPUT BY DAYS OF THE WEEK FOR EACH OPERATOR SEPARATELY
FIRST RELAY ASSEMBLY GROUP

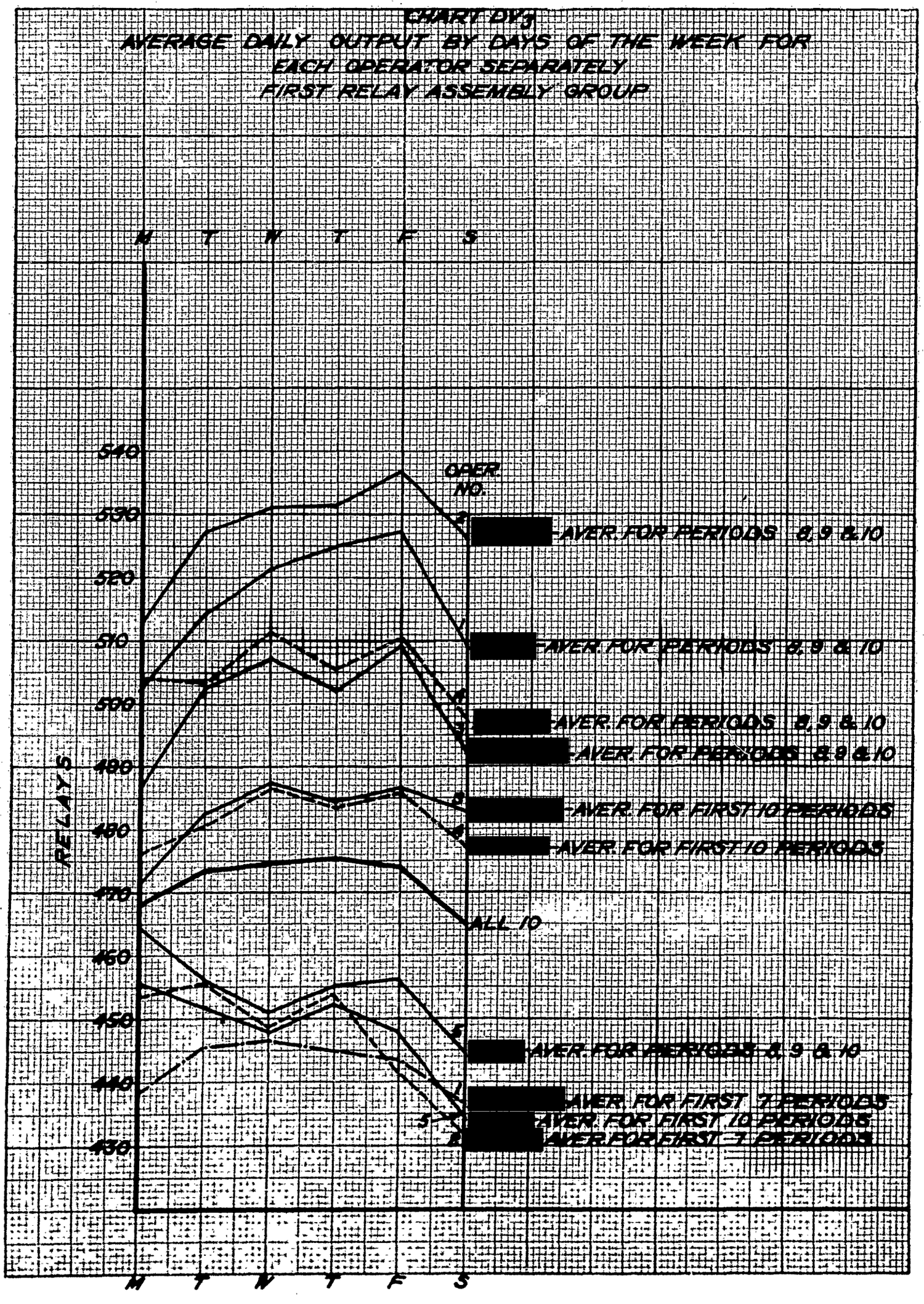


TABLE
SUPPLEMENTAL DATA ON OUTPUT BY DAYS OF THE WEEK
FIRST RELAY ASSEMBLY GROUP
(Comparison of Average Outputs of Individual Operators
For Different Days of the Week, Period No. 12)

	Operator					
	#1	#2	#3	#4	#5	Av. for Group
Monday	531.8	539.8	505.9	526.3	491.2	519.0
Tuesday	546.0	558.9	521.5	534.2	503.4	532.8
Wednesday	554.7	562.9	531.5	540.5	499.6	537.8
Thursday	557.4	571.3	527.7	537.1	484.5	535.8
Friday	562.6	574.8	532.0	544.7	485.8	539.9
Saturday	556.2	578.8	528.1	538.5	480.3	536.8

One significant fact which appears in this table for period No. 12 (full 8-3/4 hours working day) is the higher Saturday output as compared with the other features. This furnishes further evidence against the existence of cumulative fatigue. The explanation of this improvement may lie in the desire to increase earnings just before the Christmas holidays.

C. VARIATION IN OUTPUT BY HOURS OF THE DAY

How does output vary during the different hours of the day? Is the shape of the output curve for different days the same? Has there been any change in the shape of this output curve during the different periods of the study?

In order to answer these questions, computations and averages have been prepared from the output data for each successive fifteen minutes of the working day. These data are presented in the form of the following five graphs.

These data curves cover Tuesday, Wednesday, Thursday, and Friday, but not Monday and Saturday because these two days have been found to be not comparable with the other four.

A-1 The average fifteen minute output for each operator over the last three weeks of period No. 7.

A-2 The average fifteen minute output for all operators over the last three weeks of period No. 3 and period No. 4.

A-3 Average fifteen minute output for all operators during the last three weeks of period No. 5 and period No. 6.

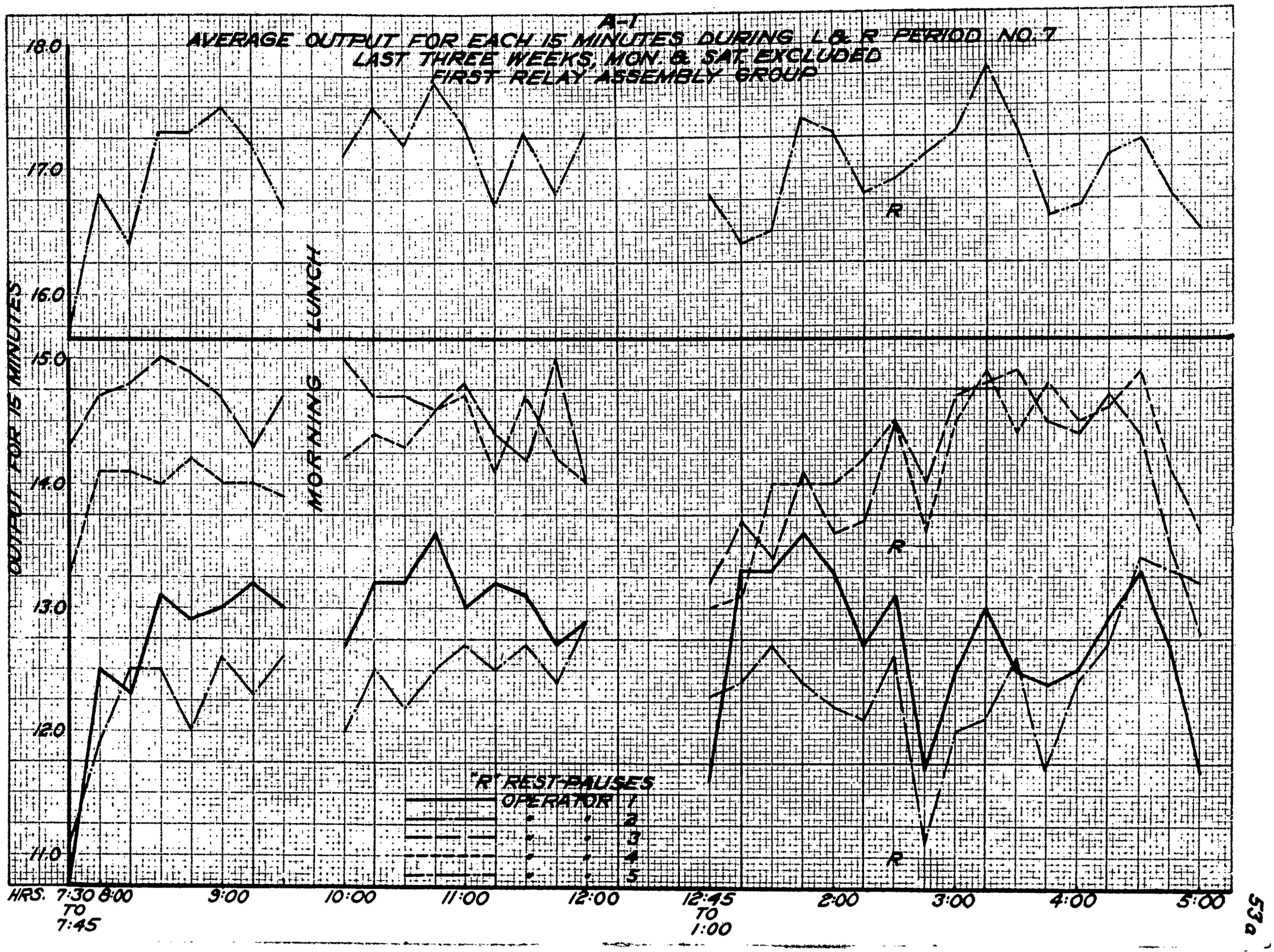
A-4 Average fifteen minute output for all operators during the last three weeks of period No. 7.

A-5 Average fifteen minute output for all operators during the last three weeks of period No. 8, and period No. 9.

A study of these graphs reveals the following facts:

1. The output curves by fifteen minute periods vary widely in shape when we compare different days, different operators, and different features.

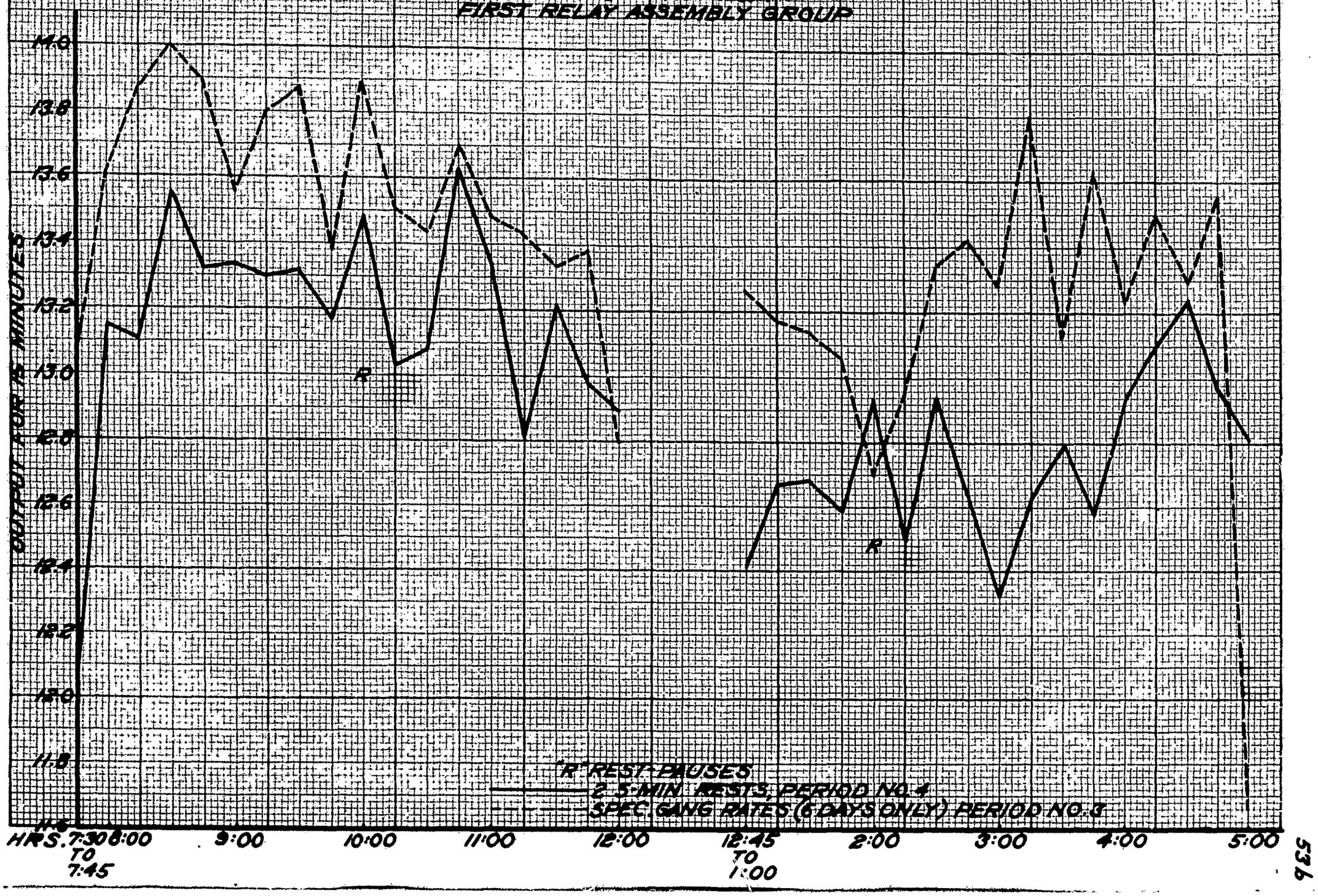
2. The afternoon output shows an appreciable improvement as compared with the forenoon output during the later features of the study where rest and lunch periods have been introduced and where the working day has been shortened.



UNIVERSITY OF WISCONSIN - MILWAUKEE

A-2

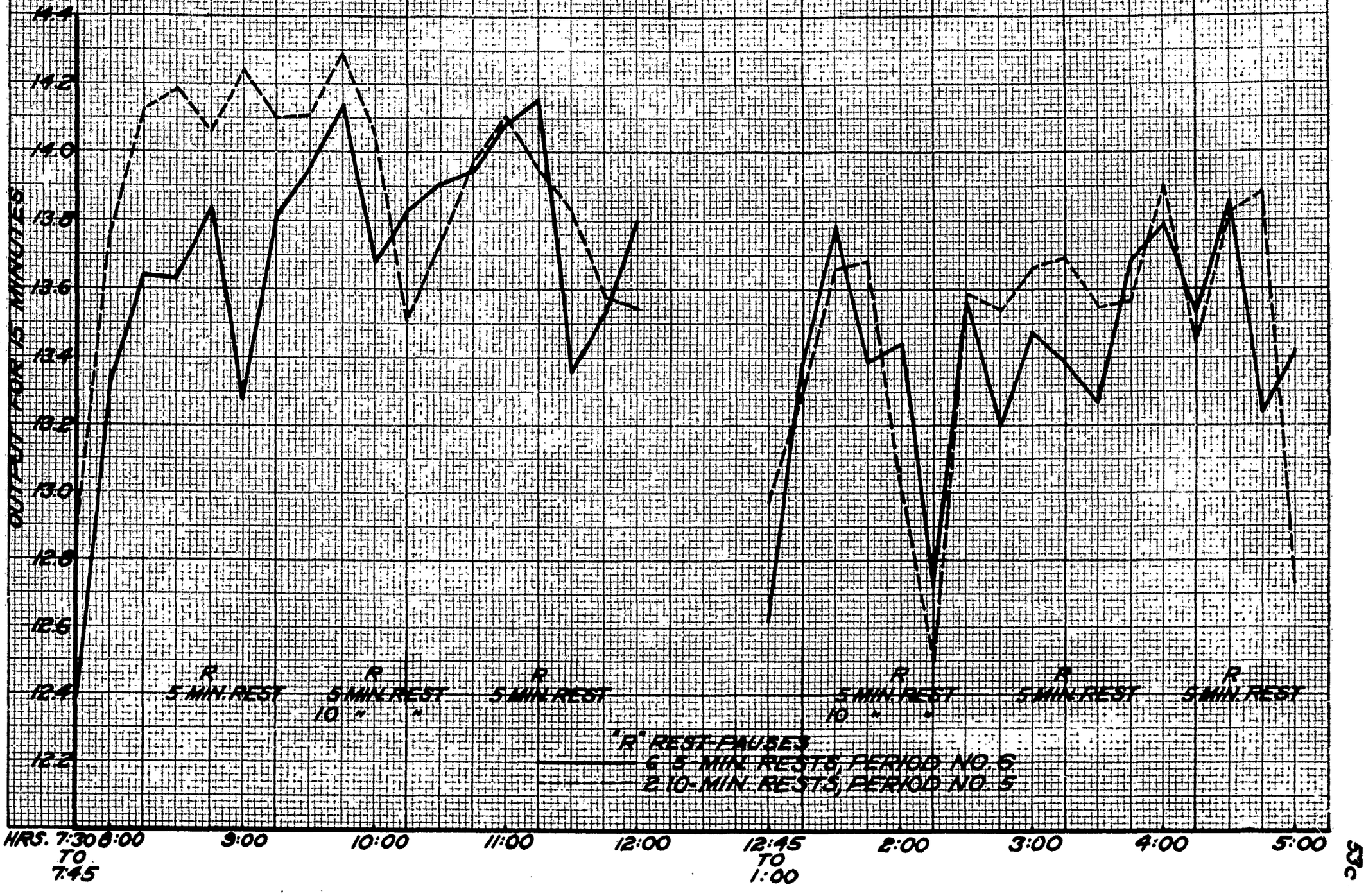
AVERAGE OUTPUT FOR EACH 15 MINUTES FOR ALL OPERATORS
LAST THREE WEEKS, MON & SAT. EXCLUDED
PERIODS NO. 3 & 4
FIRST RELAY ASSEMBLY GROUP



536

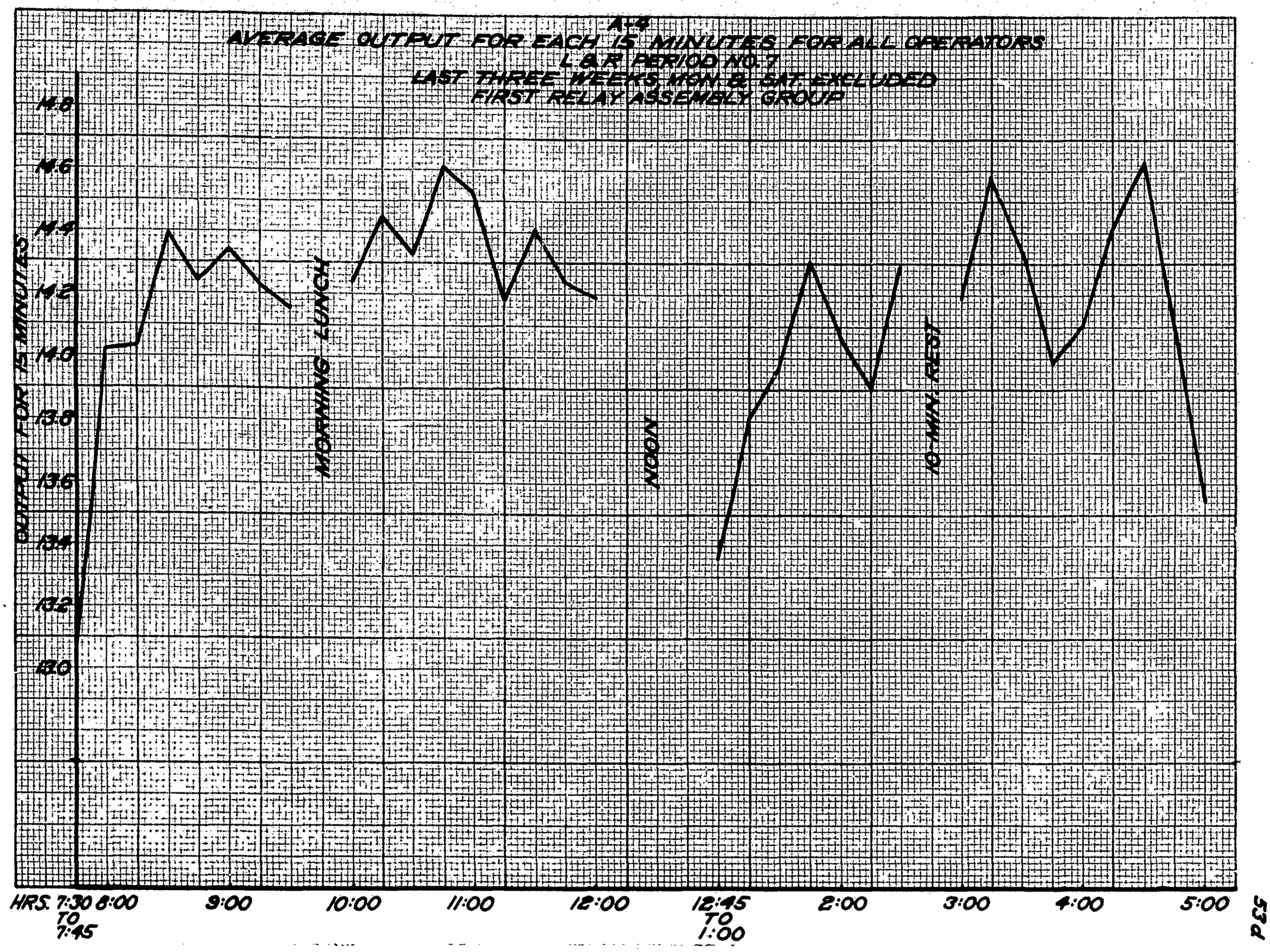
A-3

AVERAGE OUTPUT FOR EACH 15 MINUTES FOR ALL OPERATORS
LAST THREE WEEKS, MON. & SAT. EXCLUDED
PERIODS NO. 5 & 6
FIRST RELAY ASSEMBLY GROUP



A-4

AVERAGE OUTPUT FOR EACH 15 MINUTES FOR ALL OPERATORS
L & R PERIOD NO. 7
LAST THREE WEEKS, MON & SAT EXCLUDED
FIRST RELAY ASSEMBLY GROUP

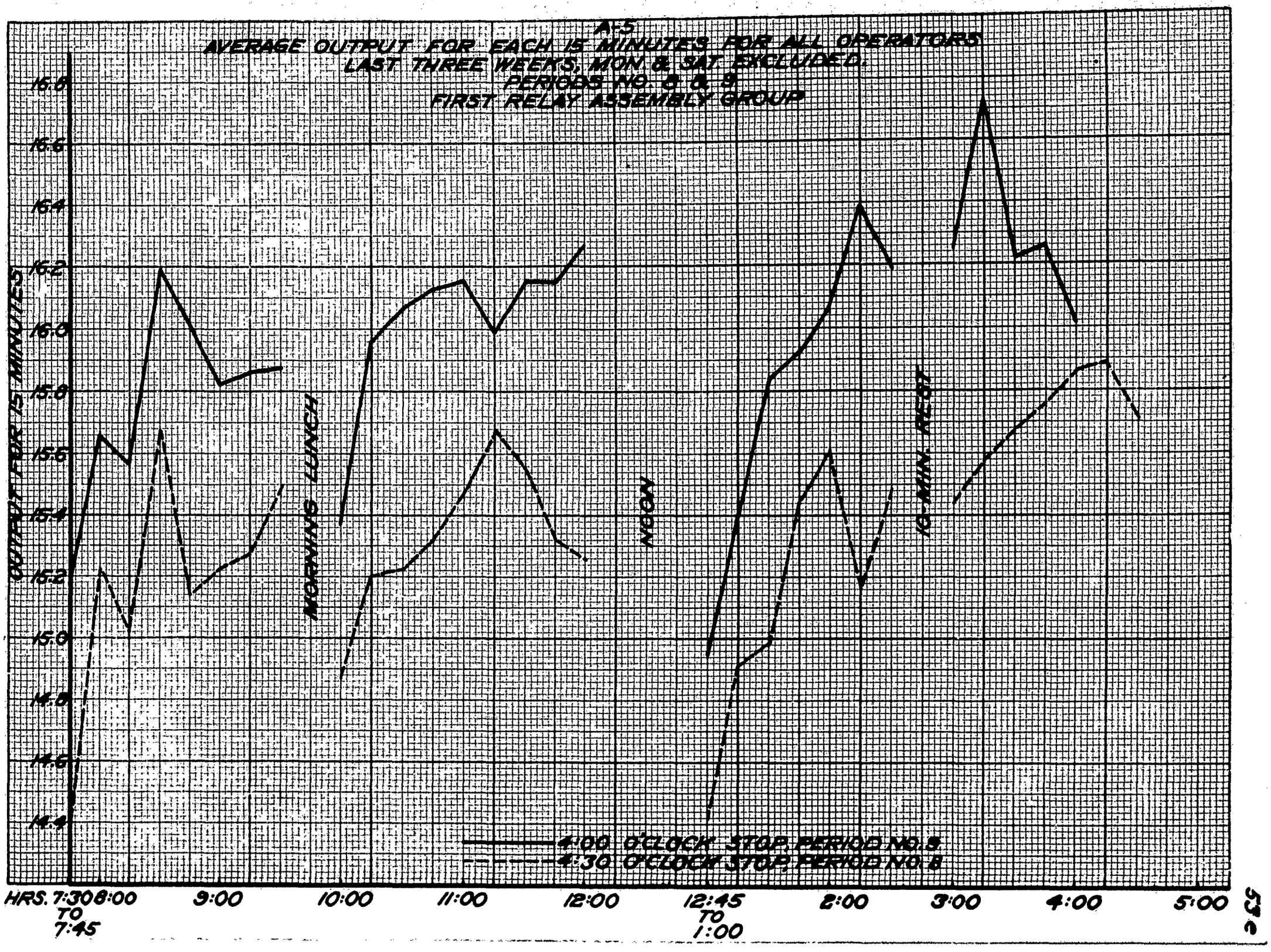


P55

UNIVERSITY OF WISCONSIN - MILWAUKEE

A-5

AVERAGE OUTPUT FOR EACH 15 MINUTES FOR ALL OPERATORS
LAST THREE WEEKS, MON & SAT EXCLUDED.
PERIODS NO. 6 & 9.
FIRST RELAY ASSEMBLY GROUP



UNIVERSITY OF WISCONSIN - MILWAUKEE

D. The following table shows that three of the four operators working upon flat type relays have a slightly higher hourly output in the afternoon than in the forenoon during the first twenty-four weeks of period No. 13. Computations are being made for operator No. 5 for this period and for other operators for other periods, but are not yet completed.

TABLE

COMPARISON OF MORNING AND AFTERNOON PERFORMANCES

Six Months - Nov. 26, 1928, through May 25, 1929.

	Operator No. 1	Operator No. 2	Operator No. 3	Operator No. 4
A. M. Average Hourly Output	60.7	64.6	59.8	62.4
P. M. Average Hourly Output	61.7	64.8	57.3	62.8
Percentage Difference A.M. to P.M.	- 1.6%	-.31%	+4.2%	-.64%

E. UNIFORMITY OF PERFORMANCE

The previous progress reports (see Appendix A of this report) have described a method by which an index of uniformity of performance is computed by measuring the tape exactly for fifteen minute intervals and determining the variation in output for each fifteen minute interval as compared with the average fifteen minute output for the day. These data were computed until the beginning of the five day week, period No. 11. It took so much time to count the tape, however, that the computations were discontinued at that time.

Trial computations of the variation by half hour intervals were made in the hope that comparable results could be obtained with a briefer method. It was found, however, that variation by half hour intervals did not check the figures previously obtained by fifteen minute intervals and did not give such a good picture of the fluctuation in the rate of production. No computations of variation were made during the five day week, period No. 11, but computations were made during the first five weeks of period No. 12 in order to see whether there was a change in variation when the operators returned to a full length day without rest periods.

The following table indicates the trend of the variation in performance for the periods shown. The figures are given by morning spell, afternoon spell, and the whole day, for individual operators.

TABLE
MORNING AND AFTERNOON VARIATIONS
Index Figures Showing Average Daily Variation by Periods

Oper. No.	Period No. 3 Special Gang Rate A.M.	P.M.	Day	Period No. 4 Two 5 Minute Rests A.M.	P.M.	Day	Period No. 5 Two 10 Minute Rests A.M.	P.M.	Day	Period No. 6 Six 5 Minute Rests A.M.	P.M.	Day
1	5.1	4.2	9.3	2.9	3.2	6.1	6.3	5.7	12.0	5.6	3.9	9.5
2	5.4	7.2	12.6	3.6	3.8	7.4	6.0	4.8	10.8	3.8	4.4	8.2
3	3.2	5.9	9.1	2.2	3.6	5.8	2.0	3.3	5.3	1.6	2.3	3.9
4	2.1	2.5	4.6	1.6	3.7	5.3	3.2	4.2	7.4	1.5	2.0	3.5
5	5.4	3.7	9.1	3.7	3.0	6.7	2.5	3.3	5.8	2.7	3.1	5.8

Oper. No.	Period No. 7 15 Min. A.M. Lunch, 10 Min. P.M. Rest A.M.	P.M.	Day	Period No. 8* 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:30 Stop A.M.	P.M.	Day	Period No. 9 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:00 Stop A.M.	P.M.	Day	Period No. 10 15 Min A.M. Lunch, 10 Min. P.M. Rest A.M.	P.M.	Day
1	3.7	3.8	7.5	*2.2	2.2	4.4	2.0	2.2	4.2	2.9	4.4	7.3
2	3.3	4.0	7.3	*3.3	3.3	6.6	3.7	3.6	7.3	4.7	6.3	11.0
3	2.2	3.8	6.0	1.7	2.7	4.4	2.0	2.3	4.3	1.7	3.3	5.0
4	1.5	3.1	4.6	0.5	1.3	1.8	1.0	1.4	2.4	1.3	2.6	3.9
5	3.4	3.7	7.1	2.6	2.0	4.6	2.5	2.7	5.2	2.9	2.5	5.4

Oper. No.	Period No. 12 No Lunches No Rests A.M.	P.M.	Day
1	4.2	6.3	10.5
2	3.8	7.4	11.2
3	2.0	5.1	7.1
4	1.7	1.4	3.1
5	2.3	2.8	5.1

* Operators No. 1 and No. 2 replaced at beginning of Period No. 8.

TABLE
TOTAL AVERAGE VARIATION OF INDIVIDUALS

Oper. No.	All Periods	Last Three Periods Only
4	4.1	3.1
3	5.6	5.5
5	6.1	5.2
1	6.6*	7.3
2	9.0*	9.8

* These figures for operators Nos. 1 and 2 are for periods Nos. 8, 9, 10, and 12 and are not directly comparable with the figures of operators Nos. 3, 4, and 5 which are averages for all periods. It will be seen, however, from the next column that the relative rating of the different operators remains fairly constant.

The following table shows the average relative variation for the group of five operators in terms of indexes of uniformity of performance for different periods.

Because operators Nos. 1 and 2 were changed, a separate column has been included to give the average index of uniformity of performance by periods for operators Nos. 3, 4, and 5.

TABLE
TOTAL AVERAGE VARIATION FOR THE GROUP

Period Number	Period or Feature	Total Average Variation Five Operators	Total Average Variation Oper. 3, 4, and 5 Only
8	**15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:30 Stop	4.4	3.6
9	15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:00 Stop	4.7	3.96
6	Six 5 Minute Rests	6.2	4.4
4	Two 5 Minute Rests	6.3	5.9
7	15 Min. A.M. Lunch, 10 Min. P.M. Rest	6.5	5.9
10	15 Min. A.M. Lunch, 10 Min. P.M. Rest	6.5	4.7
12	No Lunches, No Rests	7.4	5.1
5	Two 10 Minute Rests	8.3	6.1
3	Special Gang Rate	8.9	7.6

** Operators Nos. 1 and 2 replaced at beginning of this period.

It will be seen that there has been an appreciable variation in performance and that in general the uniformity has improved as the day has been shortened. (The fact that the uniformity for the 4:30 stop is better than that of the 4:00 o'clock stop would seem inconsistent with this general statement, but it should be remembered that operators Nos. 1 and 2 were changed at the beginning of the 4:30 stop period and probably the new operators were working particularly hard. It is possible that this situation accounts for the splendid record of uniformity during the 4:30 stop period.

It will be noted that period No. 12 shows appreciably lower variation of output than period No. 3, which was also a full length day without rest pauses.

The greater uniformity in output when rest pauses are present adds emphasis to the suggestion that operators vary their pace or take brief rest pauses on their own account when working long hours without rest pauses.

It will be seen from the uniformity of performance records of different operators that the present operators Nos. 1 and 2 who are the speediest and have the highest total output have the worst indexes of uniformity. There is wide variation in the performance of different operators, but the most uniform workers do not have the highest output.

F. QUALITY OF PRODUCTION

The output data given previously are free from complication because of variation in the quality of the product since all output figures are given in terms of perfect E-901 relays assembled. Each girl repairs her imperfect relays during regular working time. There has been no significant change in the amount of repair work necessary.

It was determined by inspecting the individual output records that there is no perceptible increase in the number of imperfect relays directly after the operator changes from one type of relay to another. It has frequently been noted that a girl increases the number of defective relays because of carelessness until her number of imperfect relays becomes large for some particular half-week whereupon by proper application she greatly reduces the number of repairs.

G. EFFECT UPON OPERATORS

1. Health

Regular physical examinations of operators in the test room have been continued. Data accumulated since the last progress report are not included herewith, but no significant changes in health status are observed in the assembly operators.

Absenteeism has been markedly reduced among these operators since they have been working in the test room. The following table is a record of absenteeism for these girls in the regular department and during the first sixteen months of the test. An item here represents any case in which the girl was sick, excused, or late. Individual records follow:

Oper. No.	Name	In Regular Department	In Test Department
1	[redacted]	10 Items - 18 Months	1 Item - 8 Months
2		71 " - 28 "	6 " - 8 "
3		29 " - 23 "	3 " -16 "
4		7 " - 43 "	1 " -16 "
5		6 " - 14 "	10 " -16 "
6		85 " - 32 "	0 " -16 "

In summarizing the above table it is found that the group averaged 15.6 absence items a year in the regular department and 3.2 absence items per year in the test room. This reduction in the number of absences to about 1/5 the former amount was quite unconscious on the part of the operators. They had not realized that their absence records had improved. The record is, therefore, all the more significant since it indicates an improvement in health or in mental attitude toward work, rather than a conscious attempt on the part of the operators, as the factor underlying improved attendance.

*Layout Operator

For the sake of comparison, data have been gathered concerning absence and lateness for a group of thirty-three girls in the regular Relay Assembly Department. These girls have consecutive numbers on the Company attendance records and represent a random sampling.

The following table shows the comparative standing of the test room group and the regular department group:

TABLE ___

ATTENDANCE IRREGULARITIES

Comparison of Test Room to Department 6329

Six Month Period - Nov. 1, 1928 Through Apr. 30, 1929

	Sick	Excused	Absent	Late	Failure To Register
Test Room Total (6 girls)	12 days	1½ days	2½ days	7 times	2 times
Average Per Individual	2.0 "	.25 "	.42 "	1.17 "	.33 "
Dept. Total (33 girls)	23½ "	20½ "	40 "	34 "	30 "
Average Per Individual	7 "	.62 "	1.21 "	1.03 "	.91 "
Irregularities of Test Room Group on Basis of 100 Persons	200	25	42	117	33
Irregularities of Department 6329 Group on Basis of 100 Persons	700	62	121	103	91

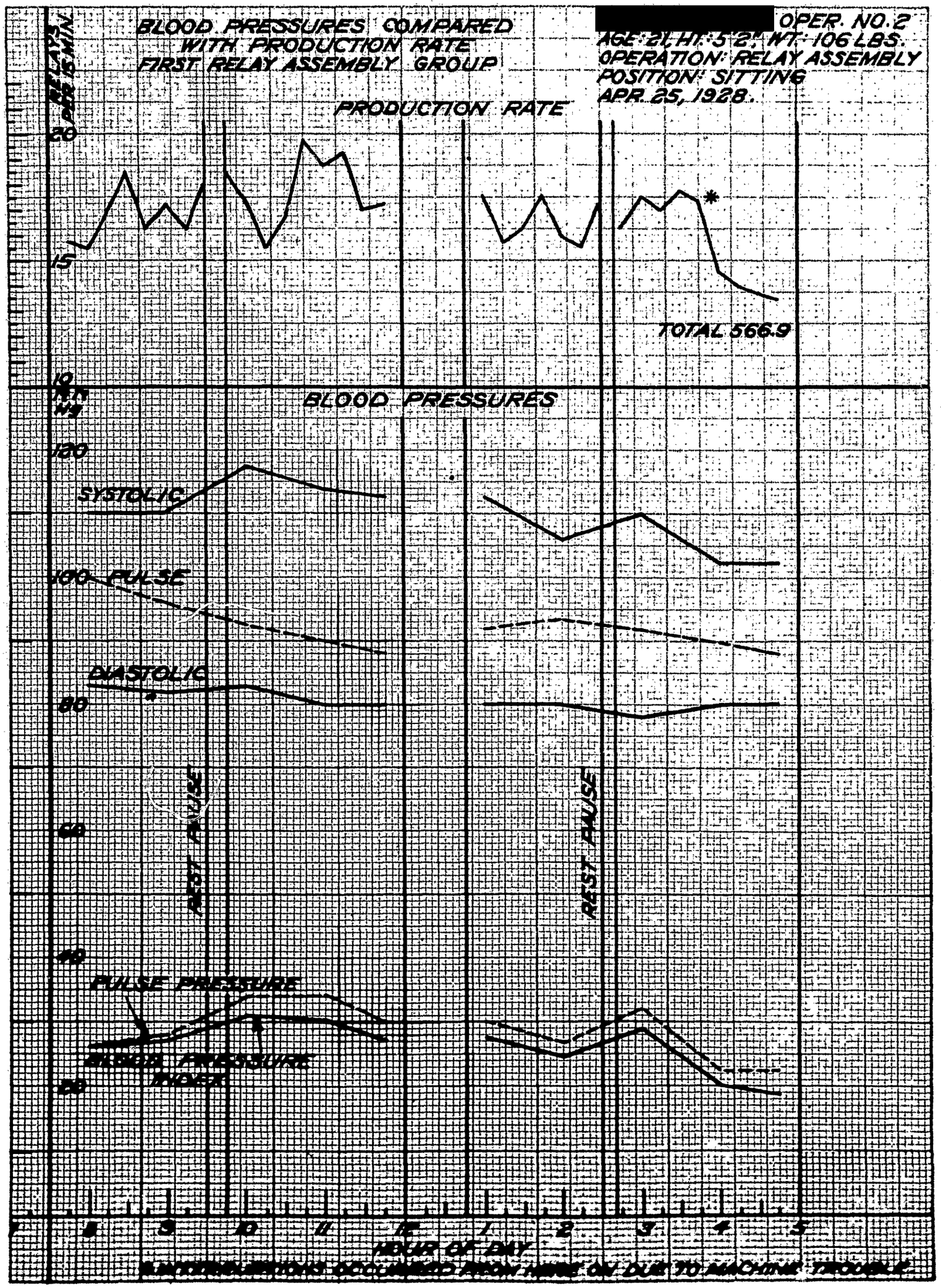
With respect to these items, it will be noticed that the girls in the regular department have about three and one-half times as many sick absences, about two and one-half times as many excused absences, about three times as many other absences, and about three times as many failures to register.

A second set of blood pressure readings, taken on November 14, 1928, also indicate the maintenance or improvement of the health status. The following graphs include - (1) the chart made for operator No.2 from the readings of April 25, 1928, and (2) the average blood pressure indexes for various groups of workers compiled by Dr. Mayo. These two charts were in the previous progress report. We have also added here (3) the chart for operator No. 2 from the readings taken November 14, 1928, and (4) a second chart giving the blood pressure index for each operator and for the group of operators as a whole for the November 14, 1928, reading.

It will be recalled that the index here used is a product of the pulse pressure and the pulse rate. It is the belief of those who have worked most with this test that the index tends to remain low and relatively steady in those operators who are working within their physical capacity. On the other hand, it is believed that operators who are working beyond their capacity will have an irregular index which tends to go up as fatigue increases toward the end of the day.

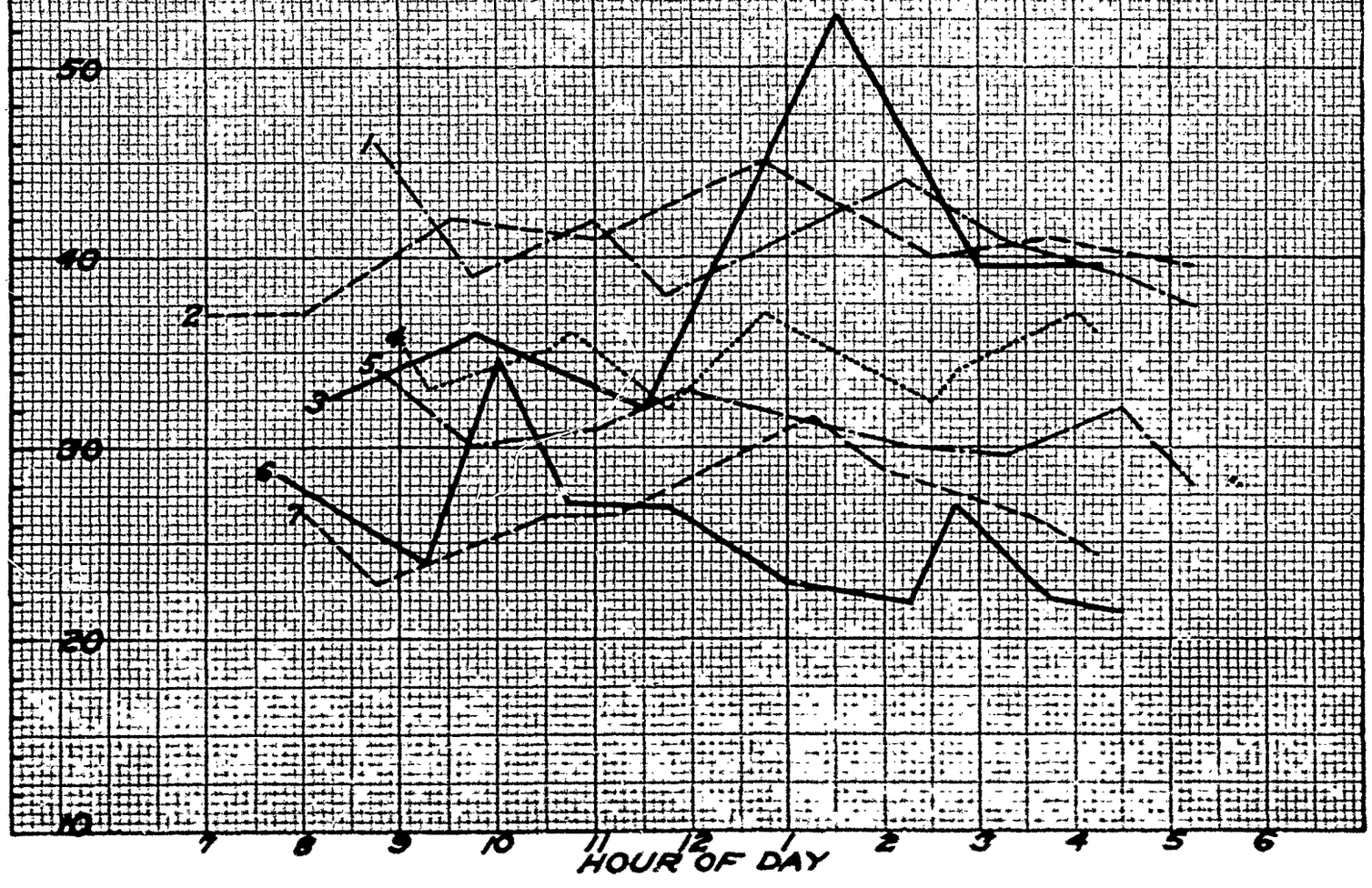
It will be seen by comparing the two charts for operator No. 2, which follow, that both sets of readings are highly satisfactory. While the second set of readings is slightly higher it will be noted that the high points are at the beginning of the forenoon and afternoon work period while the index steadily declines as production increases and the day advances.

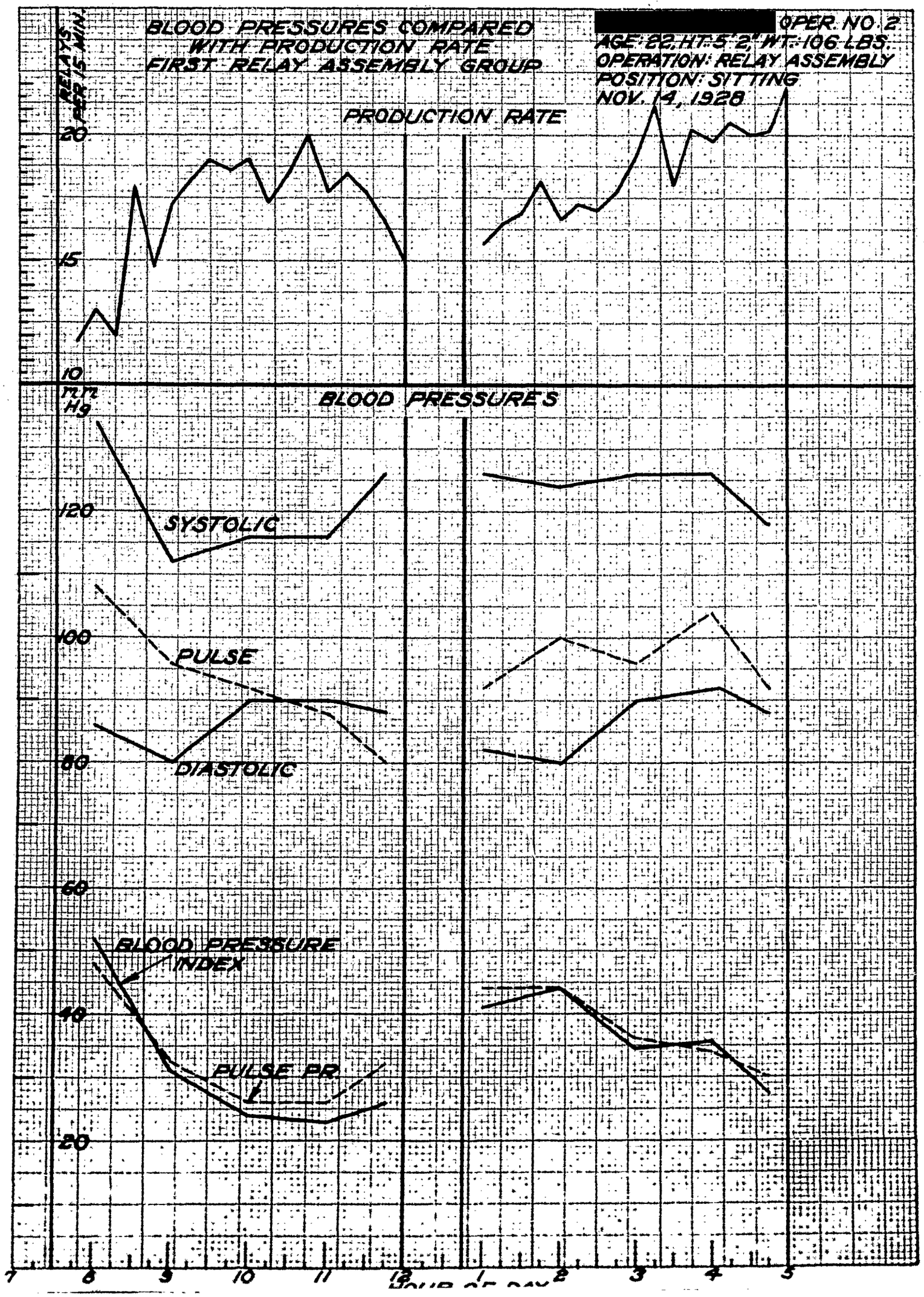
Comparison of the charts showing the index for individual operators and the average for the group as a whole with the "average height of index" chart for other groups of workers shows that these operators at the last readings, as well as at the first, have a better record than the other groups of workers studied by Dr. Mayo since the index remains lower and has a satisfactory downward tendency as output increases and the day advances. These readings indicate that the health status is being satisfactorily maintained.


BLOOD PRESSURES COMPARED
WITH PRODUCTION RATE
FIRST RELAY ASSEMBLY GROUP
[redacted] OPER. NO. 2
AGE: 21, HT.: 5' 2", WT.: 106 LBS.
OPERATION: RELAY ASSEMBLY
POSITION: SITTING
APR. 25, 1928.
PRODUCTION RATE
RELAYS PER 15 MIN.
20
15
TOTAL 566.9
BLOOD PRESSURES
MM Hg
120
SYSTOLIC
100 PULSE
DIASTOLIC
80
60
REST PULSE
40
PULSE PRESSURE
20
BLOOD PRESSURE INDEX
8
9
10
11
12
1
2
3
4
5
HOUR OF DAY
NO OBSERVATIONS OBTAINED THIS HOUR OR DUE TO MACHINE TROUBLE

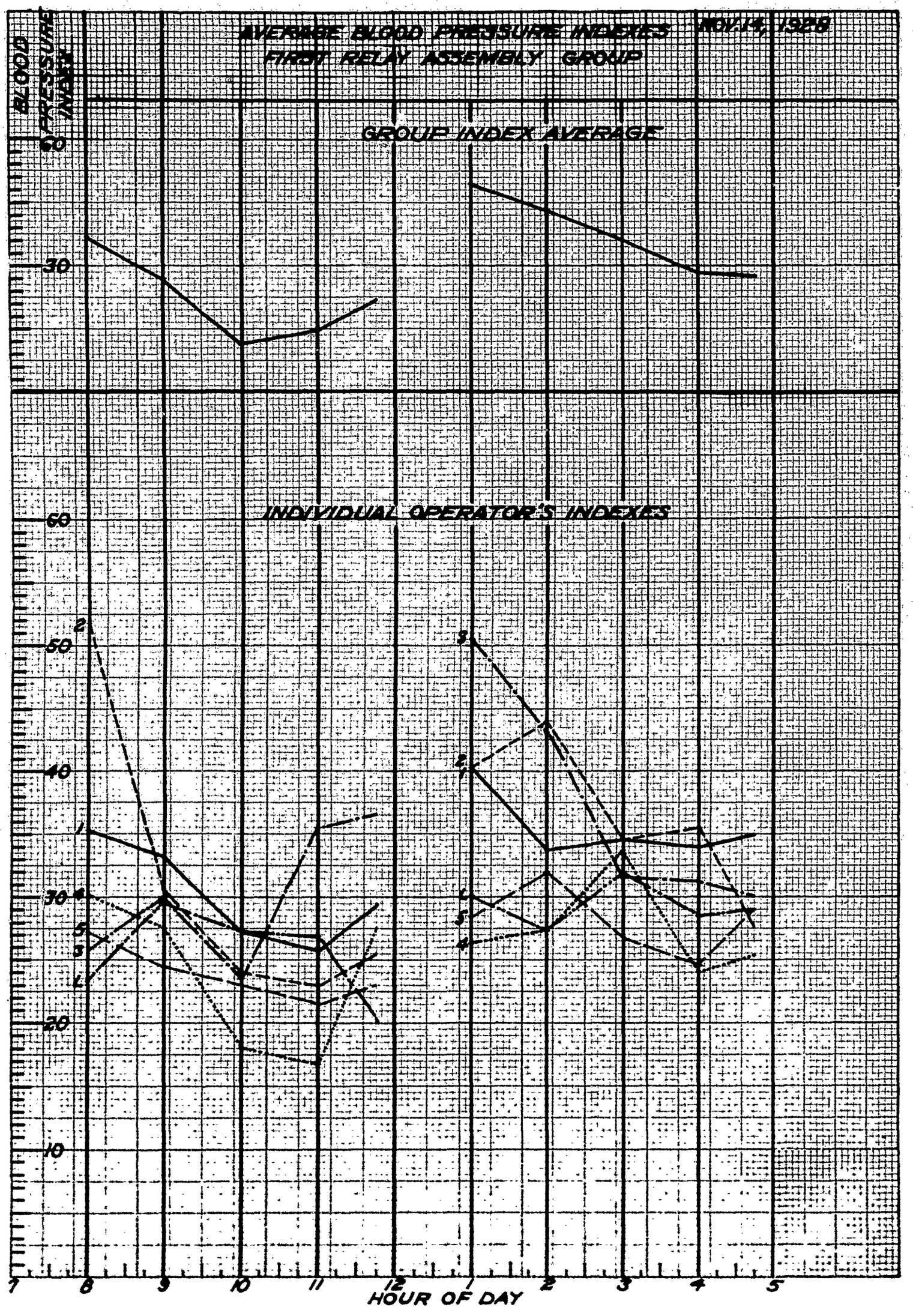
AVERAGE HEIGHTS OF BLOOD PRESSURE INDEX

COMPANY	JOB	POSITION	SUBJECTS	READINGS PER POINT	AV. FIGURE	NO. BELOW
WM. CARTER CO.	INSPECTING AND FOLDING UNDERWEAR	STANDING TWO 10 MIN. REST PERIODS	4	6	40.75	1
AMERICAN PULLEY CO.	MACHINE SHOP	STANDING NO REST PERIODS	9	9	40.30	2
CONTINENTAL MILLS	MULE SPINNING	WALKING FOUR 10 MIN. REST PERIODS	6	6	34.80	4
WESTERN ELECTRIC CO.	CORE WINDING	SITTING NO REST - PERIODS	3	3	38.78	3
WM. CARTER CO.	RUNNING POWER SEWING MACHINES	SITTING TWO 10 MIN. REST PERIODS	3	6	30.94	5
WESTERN ELECTRIC CO.	RELAY ASSEMBLY (TEST ROOM APRIL 25, 1928)	SITTING ONE 15 MIN.) ONE 10 MIN.) REST PERIOD	5	5	26.74	6
WESTERN ELECTRIC CO.	SAME APRIL 26, 1928	SAME	5	5	25.54	7





UNIVERSITY OF WISCONSIN - MILWAUKEE


AVERAGE BLOOD PRESSURE INDEXES
FIRST RELAY ASSEMBLY GROUP
NOV. 14, 1928
BLOOD PRESSURE INDEX
GROUP INDEX AVERAGE
INDIVIDUAL OPERATOR'S INDEXES
60
50
40
30
20
10
HOUR OF DAY
7
8
9
10
11
12
1
2
3
4
5

Data concerning the daily practices of operators with respect to food, sleep, and activity have been gathered. Some of these original data were included in the previous progress report. Further data are not added in this supplementary report because there is nothing new of special significance. There has been no important change in the daily habits of the operators outside the factory. Their program of living is fairly good. A typical day's schedule taken from their report includes: rising at six o'clock, a light breakfast or sometimes no breakfast, the day's work at the factory, one to two hours of housework, a walk of one to two miles, occasional special entertainment, and retiring at 10 o'clock. It has been already pointed out that the mid-morning lunch supplements the breakfast and makes the noon lunch lighter with a consequent improvement in working condition in the afternoon. Hours of sleep are widely varying and a discussion of their effect is included elsewhere in this report.

2. Mental Attitude

The mental attitude of the operators has materially, consistently, and continually improved under the experimental conditions. The previous progress report discussed this item in detail pointing out the specific conditions in the test room which tended to improve the contentment of the worker and her attitude toward her work.

The recording of comments of operators has been continued, but these details are not included in the present supplementary report. The significant fact is a continuance of an ideal mental attitude on the part of the operators and the further development of understanding and confidence between the operators and those in charge of the experiment.

The following typical and selected comments with reference to period No. 12 (48 hour week) reflect (a) the dread and dislike of monotony, (b) the feeling of fatigue (or ennui) during the 8-3/4 hour day, and (c) the difficulty in getting a hearty breakfast. The following comments were made near the end of period No. 11 (5 day week):

"Nothing to look forward to, no eats, no rests."
"It is not so much the working on Saturday mornings as it is the loss of the rest periods. I dread that."
"I'll have to get up at five to get breakfast."

The following comments were made during period No. 12 (48 hour week):

"I always feel tired now during the day. The noise is terrible."
"Too monotonous. I'll go crazy."
"I'm so tired."
"Days seem long."
"More tired now."

SECTION III

THE INTERPRETATION OF RESULTS

A. ACCIDENTAL FACTORS IN WORKING CONDITIONS WHICH MAY EFFECT RESULTS

It is of obvious importance to consider every possible cause for fluctuations in output when interpreting such data as has been collected in this study. Any new or recurring condition which appears during the experiment is worthy of examination in safeguarding the interpretation of results. It will be seen that a knowledge of the effect of such factors as are here considered will also be worth while from the standpoint of industrial management.

1. Seasonal Variation

In the previous progress report data were presented showing the average monthly earnings for a gang of about 5500 piece work operators over a period of three years and a separate output curve for a single year covering the work of 29 operators from March, 1927, to March, 1928. (See Appendix B of this report.) These curves all showed a consistent seasonal fluctuation with the high output in November each year and a smaller peak in April or May while the low points of the curve were January and midsummer. These fluctuations in earnings were of a magnitude equal to about 2% of the base rate. These variations are not enough to affect the experimental data although some definite improvement in output in fall and spring may be expected.

2. The Effect of Changing the Type of Relay Upon which the Girls are Working

A special study was made to determine the effect upon output caused by changing the type of relays upon which operators were working. This study was made because the girls in the test room were kept at work upon those types of relays which were being made in large quantity at Hawthorne whereas the girls in the large gang outside worked upon many different kinds of relays and consequently changed types frequently. It seemed plausible that it might take the operator a few hours to accustom herself to working on a new type of relay. If this were the case then the less frequent changes of type in the test room would be a factor in producing the increased output from these operators.

In order to test this hypothesis the output records for operators Nos. 1, 2, 3, and 4* were checked for each instance in which the girl changed from one type of relay to another, working on the second type of relay for at least a full day thereafter. Then the hourly output for the operator during the first hour's work on the new relay and the average hourly output during the first full day's work thereafter were computed. If changing the type of relay is a handicap to output, one would expect to find a distinctly lower output for the first hour after the change than the average for the first full day. The data collected are shown on the following pages. It will be noted that:

(a) The output for the first hour after a change of type is often higher than the average for the first full day thereafter.

(b) For two of the four operators the average output for the "first hour" was higher and in the other two operators it was lower than the average for the "first day".

(c) There is no significant difference in the output for the "first hour" as compared with that for the "first day."

We may conclude that the change from one type of relay to another familiar type does not slow up production. Apparently if greater difficulty is experienced in assembling the second type of relay, it is compensated for by greater attention. Occasionally operators in the regular shop may have very frequent changes and unfamiliar types, but in general they would work at least an hour on a type. Fewer changes in type does not appear to be a factor in the increased output in the test room.

---

*Data were not collected for operator No. 5 since she is working on round rather than flat relays and is continually changing types throughout the day.

TABLE
EFFECT ON OUTPUTS OF CHANGING TYPES OF RELAYS

Oper. No. 1

Period	Date	Actual Time Used to Compute 1st Hour	Average Output 1st Hour After Change		Date of 1st Full Day's Output	Average Hourly Output 1st Day After Converted to E-901
			Actual	Converted to E-901		
No. 8 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:30 Stop	1-25-28	7:35- 8:40	49.9	54.9	1-26-28	62.2
	2- 8-28	9:13-10:20	57.7	63.5	2- 9-28	66.9
	2-16-28	12:48- 1:35	63.9	70.4	2-17-28	68.5
	2-22-28	1:30- 2:28	61.3	67.5	2-23-28	64.0
No. 9 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:00 Stop	3-31-28	7:30- 8:25	54.6	60.1	3-31-28	65.5
No. 10 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest	4-25-28	3:22- 4:10	62.5	62.5	4-26-28	59.5
	5- 8-28	8:37- 9:30	56.6	62.3	5- 9-28	62.1
	5-10-28	10:35-11:25	60.0	60.0	5-11-28	61.8
	"	2:23- 3:30	52.7	58.0	5-19-28	63.8
	"	11:13-11:45	63.8	63.8	5-28-28	62.3
	"	8:54-10:00 P-:09	58.8	64.6	6- 9-28	63.5
No. 12 - No Lunches, No Rests	10-12-28	11:09-12:55 P-:09	57.7	63.5	10-13-28	64.5
	10-23-28	11:23- 1:10	56.6	62.3	10-24-28	60.0
	Average		62.6		63.4	

.P-Personal time out deducted when figuring the output for the first hour.

Oper. No. 2

Period	Date	Actual Time Used to Compute 1st Hour	Average Output 1st Hour After Change Actual	Converted to E-901	Date of 1st Full Day's Output	Average Hourly Output 1st Day After Converted to E-901
No. 8 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:30 Stop	1-25-28	7:35- 8:15	55.6	61.2	1-26-28	63.2
	2- 8-28	9:05-10:00	60.0	66.1	2- 9-28	67.9
	2-16-28	1:01- 1:45	68.2	75.1	2-17-28	70.8
	2-22-28	1:44- 2:41	63.9	70.4	2-23-28	65.2
No. 9 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:00 Stop	3-31-28	8:11- 9:00	61.3	67.5	4- 2-28	64.9
No. 10 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest	4-25-28	3:19- 4:00 P-:03	73.2	73.2	4-26-28	60.1
	5-18-28	11:29- 1:00	69.8	76.8	5-19-28	69.3
	5-26-28	10:40-11:30	60.0	60.0	5-28-28	62.2
	6- 8-28	8:34- 9:20 P-:08	65.3	71.9	6- 9-28	68.8
No. 12 - No Lunches, No Rests	10-12-28	10:54-11:45 P-:09	69.8	76.8	10-13-28	65.2
	10-23-28	11:35- 1:25	53.6	59.0	10-24-28	62.7
		Average	63.7			65.5

P - Personal time out deducted when figuring the output for the first hour.

- Oper. No. 3

Period	Date	Actual Time Used to Compute 1st Hour	Average Output 1st Hour After Change Actual	Converted To E-901	Date of 1st Full Day's Output	Average Hourly Output 1st Day After Converted to E-901
No. 2 - Introduction to test room	5-31-27	8:10- 9:20	42.7	42.7	6- 1-27	39.7
	6- 2-27	4:42- 5:00	26.7	29.4	6- 3-27	51.5
	6- 7-27	9:00-10:00	50.0	55.1	6- 8-27	50.3
No. 3 - Special Gang Rates	6-17-27	9:50-10:55	46.3	51.0	6-20-27	50.5
	6-22-27	11:30- 1:00	46.7	51.4	6-23-27	53.6
"	6-25-27	8:37- 9:35	51.5	51.5	6-27-27	47.4
"	6-30-27	1:20- 2:20	50.0	55.1	7- 1-27	53.8
"		R-:02 P-:07				
"	7- 8-27	11:13- 1:15	44.2	45.5	7- 9-27	54.4
"	7-11-27	8:17- 9:10	56.6	56.6	7-12-27	51.7
"	7-20-27	11:41- 1:25	50.9	50.9	7-21-27	55.0
"	7-23-27	8:26- 9:30	46.7	59.1	7-25-27	54.6
"	7-27-27	4:25- 5:00	36.2	45.8	7-28-27	53.0
"	8- 1-27	8:25- 9:25	50.0	55.1	8- 2-27	54.6
No. 4 - Two 5 Min. Rests	8- 8-27	8:25- 9:00	51.5	51.5	8- 9-27	54.5
	8-11-27	11:27- 1:15 P- :03	47.6	53.0	8-12-27	51.2
No. 5 - Two 10 Min. Rests	9-26-27	11:29- 1:15	51.5	56.7	9-27-27	58.2
	9-29-27	1:41- 2:50	51.0	56.2	9-30-27	58.4
No. 6 - Six 5 Min. Rests	10-14-27	3:55- 5:00	48.0	43.2	10-15-27	50.3
	10-18-27	9:11-10:10	55.6	61.2	10-19-27	60.5
"	10-29-27	9:15-10:20	50.0	55.1	10-31-27	52.5
"	11- 2-27	8:32- 9:30	56.8	62.5	11- 3-27	63.6
No. 7 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest	11-22-27	7:30- 7:50	51.5	56.7	11-22-27	57.1
	12-14-27	7:30- 8:15	61.3	67.5	12-14-27	61.1
	1-11-28	8:25- 9:20	54.6	60.1	1-12-28	63.4
"	1-13-28	8:00- 8:50	60.0	66.1	1-14-28	63.7
No. 8 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:30 Stop	2- 8-28	10:08-11:00	57.7	63.5	2- 9-28	63.6
	2-14-28	8:17- 9:05	62.5	68.8	2-15-28	66.2
	2-21-28	1:47- 2:50	56.8	62.5	2-22-28	63.2
No. 9 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:00 Stop	3-30-28	2:18- 3:13	66.7	66.7	3-13-28	62.8
No. 10 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest,	5- 2-28	7:53- 8:40	65.1	71.7	5- 3-28	59.8
	5-19-28	8:31- 9:20	61.3	67.5	5-[illegible]-28	64.6
	5-25-28	3:28- 4:16	62.5	68.8	5-26-28	61.5
"	6- 8-28	8:47- 9:50 Fat.-:01	62.5	68.8	6- 9-28	62.3
No. 12 - No Lunches, No Rests	10-20-28	7:54- 8:45	60.0	66.1	10-22-28	53.8
		Average	57.2			56.5

P - Personal time out deducted when figuring the output for the first hour.
R - Part of rest pause deducted when pause overlapped first hour.
Fat. - Time deducted on account of fatigue reading during first hour.

Period	Date	Actual Time Used to Compute 1st Hour	Average Output 1st Hour After Change Actual	Converted To E-901	Date of 1st Full Day's Output	Average Hourly Output 1st Day After Converted to E-901
No. 3 - Special Gang Rates	6-21-27	1:32- 2:30	51.8	53.3	6-22-27	50.5
	7- 5-27	7:30- 8:45	40.0	52.7	7- 5-27	49.0
"	7-11-27	1:57- 3:00	47.6	47.6	7-12-27	53.4
"	7-15-27	11:29- 1:10	53.6	59.0	7-16-27	54.1
"	7-25-27	1:59- 3:05	45.5	59.9	7-26-27	54.8
"	7-27-27	7:37- 8:35	51.8	57.0	7-28-27	51.0
"	7-30-27	10:07-11:10	56.8	62.5	8- 1-27	51.1
No. 4 - Two 5 Min. Rests	8-13-27	10:00-11:05	50.0	55.1	8-14-27	51.0
	8-20-27	8:25- 9:25	50.0	55.1	8-22-27	54.8
"	8-31-27	3:13- 4:16	47.6	52.4	9- 1-27	53.5
No. 5 - Two 10 Min. Rests	9-16-27	3:01- 4:00 P-:05	50.9	56.0	9-17-27	58.3
"	9-26-27	10:41-11:50	46.7	51.4	9-27-27	58.2
"	9-28-27	2:17- 3:20	47.6	52.4	9-29-27	56.2
"	9-30-27	10:00-11:05	54.6	60.1	10- 1-27	59.6
"	10- 6-27	7:51- 8:50	52.6	57.9	10- 2-27	59.8
No. 6 - Six 5 Min. Rests	10-11-27	4:39- 5:00	45.7	50.3	10-12-27	57.0
	10-14-27	3:10- 4:30	40.0	50.6	10-15-27	53.3
"	10-17-27	11:41- 1:25	51.0	56.2	10-18-27	58.7
"	10-28-27	4:17- 5:00	45.8	50.4	10-29-27	54.0
"	11- 2-27	8:17- 9:20	51.8	57.0	11- 3-27	63.4
No. 7 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest	11- 7-27	1:33- 2:25	57.7	63.5	11- 8-27	56.2
	11-11-27	8:22- 9:20	51.8	57.0	11-12-27	55.0
	12-14-27	7:30- 8:20	57.6	63.4	12-14-27	60.5
"	12-22-27	10:19-11:15	53.8	59.2	12-23-27	60.1
"	1-11-28	7:44- 8:40	53.8	59.2	1-12-28	61.3
"	1-13-28	8:28- 9:20	57.7	63.5	1-14-28	60.8
No. 8 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:30 Stop	2- 8-28	10:56-11:45	61.3	67.5	2- 9-28	64.2
	2-13-28	2:42- 3:30	62.5	68.8	2-14-28	63.1
	2-21-28	1:33- 2:30	52.6	57.9	2-22-28	64.1
No. 9 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:00 Stop	3-30-28	2:50- 3:30	75.0	75.0	3-31-28	63.3
No. 10 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest	5- 2-28	7:44- 8:30	65.3	71.9	5- 3-28	63.8
	5- 8-28	8:21- 9:10	61.3	67.5	5- 9-28	61.6
	5-10-28	10:06-10:55	61.3	67.5	5-11-28	61.9
"	5-19-28	8:23- 9:15 P-:07	57.7	63.5	5-21-28	64.2
"	5-25-28	4:06- 5:00	56.2	61.9	5-26-28	64.8
"	6- 8-28	8:56-10:00	61.3	67.5	6- 9-28	63.5
No. 12 - No Lunches, No Rests	10-18-28	2:17- 3:10	56.6	62.3	10-19-28	59.8
	10-20-28	Fat.-:01 7:56- 8:50	56.6	62.3	10-22-28	59.0
		Average	59.4			58.1

P - Personal time deducted when figuring the output for the first hour.
Fat. - Time deducted on account of fatigue reading during first hour.

3. The Effect of Periodic Illness

It was desirable to know whether periodic illness would affect the output for particular weeks. It has generally been assumed that output is decreased during the menstrual period and in certain types of work this is known to be so. It seemed worth while to know the effect of periodic illness upon work of the relay-assembly type.

The dates of certain sick periods were recorded in the hospital records at the time regular examinations were made and dates for other periods were estimated from these. The data on file show the output of each operator during the week in which periodic illness occurs and the average output of that week compared with the average output for the test period. These data indicate that there is no reduction in output during the week of periodic illness, for

(a) The average output for the various operators during the week in which the monthly period occurred show 21 instances in which the average was higher than that for the test period and 13 instances in which it was lower.

(b) The average hourly output for all operators during the weeks in question was .6 of a relay greater than would have been the case if the average output for the entire test period had been maintained.

(c) The reduction in daily output due to periodic illness is not as great as that caused by the week end break in work since in 20 out of 29 instances the average hourly output for Saturday or Monday of the week in question was lower than that for any other day during periodic illness.

The detailed data are included in the table on the following pages.

TABLE
Date on Output During
Periodic Illness

Oper. No. 1

Period of Test	Date of Sick Period	Average Hourly Output	Average Hourly Output of Complete Test Period	Per cent + of "Sick Period" Compared to Complete Test Period
No. 8 - 15 Min.	Mon. 2-13-28	58.0		
A.M. Lunch, 10	Tue. 14	60.0		
Min. P.M. Rest,	Wed. 15	64.9		
4:30 Stop	Thur.**16	69.1		
	Fri. 17	68.5		
	Sat. 18	62.3		
	Average	63.8	62.7	+ 1.8
No. 9 - 15 Min.	Mon. 3-12-28	63.5		
A.M. Lunch, 10	Tue. 13	64.4		
Min. P.M. Rest,	Wed. 14	67.8		
4:00 Stop	Thur.**15	66.9		
	Fri. 16	67.1		
	Sat. 17	63.0		
	Average	65.4	65.5	- .2
No. 10 - 15 Min.	Mon. 4-9-28	66.4		
A.M. Lunch, 10	Tue. 10	64.0		
Min. P.M. Rest	Wed. 11	67.3		
	Thur. *12	67.3		
	Fri. 13	68.4		
	Sat. 14	68.6		
	Average	67.0	64.0	+ 4.7
	Mon. 5-14-28	61.1		
	Tue. 15	60.1		
	Wed. 16	60.2		
	Thur. *17	63.6		
	Fri. 18	64.0		
	Sat. 19	63.8		
	Average	62.1	64.0	- 3
	Sat. 6-9-28	63.5		
	Sun. 10	Sunday		
	Mon. 11	63.4		
	Tue. *12	65.9		
	Wed. 13	64.9		
	Thur. 14	64.3		
	Fri. 15	64.2		
	Sat. 16	65.0		
	Average	64.5	64.0	+ .8

* Periods taken from medical reports.
** Period dates established by estimation.

Period of Test	Date of Sick Period	Average Hourly Output	Average Hourly Output of Complete Test Period	Per Cent + of "Sick Period" Compared to Complete Test Period
No. 11 - 15 Min.	Fri. 7-6-28	67.8		
A.M. Lunch, 10	Sat. 7	No Work		
Min. P.M. Rest,	Sun. 8	Sunday		
Saturday A.M.	Mon. 9	62.6		
off	Tue. **10	65.8		
	Wed. 11	66.0		
	Thur. 12	67.9		
	Fri. 13	66.7		
	Average	66.1	65.7	+ .6
	Thur. 8-30-28	68.5		
	Fri. 31	65.0		
	Sat. *9-1-28	No Work		
	Average	66.7	65.7	+ 1.5
No. 12 - No	Sun. 9-2-28	Sunday		
Lunches, No	Mon. 3	Holiday		
Rests	Tue. 4	59.4		
	Average	59.4	62.1#	- 4.3

* Periods taken from medical reports.
** Period dates established by estimation.
\# For the first nine weeks of this period.

Oper. No. 2.

Period of Test	Date of Sick Period	Average Hourly Output	Average Hourly Output of Complete Test Period	Per Cent + of "Sick Period" Compared to Complete Test Period
No. 8 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:30 Stop	Mon. 1-23-28	Old No.2		
	Tue. 24	" "		
	Wed. 25	59.8		
	Thur.**26	63.2		
	Fri. 27	66.3		
	Sat. 28	65.0		
	Average	63.6	64.4	- 1.2
	Mon. 2-20-28	61.5		
	Tue. 21	65.8		
	Wed. 22	64.9		
	Thur.**23	65.2		
	Fri. 24	66.7		
	Sat. 25	65.2		
	Average	64.9	64.4	+ .8
No. 9 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, 4:00 Stop	Mon. 3-19-28	64.2		
	Tue. 20	69.6		
	Wed. 21	67.7		
	Thur.**22	68.6		
	Fri. 23	68.0		
	Sat. 24	67.2		
	Average	67.6	68.0	- .6
No. 10 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest	Mon. 4-16-28	65.5		
	Tue. 17	68.8		
	Wed. 18	72.4		
	Thur.**19	71.7		
	Fri. 20	68.8		
	Sat. 21	68.2		
	Average	69.2	65.0	+ 6.5
	Mon. 5-14-28	61.1		
	Tue. 15	60.7		
	Wed. 16	64.1		
	Thur. *17	65.6		
	Fri. 18	66.8		
	Sat. 19	69.2		
	Average	64.6	65.0	- .6
	Wed. 5-30-28	Holiday		
	Thur. 31	63.6		
	Fri.**6-1	69.9		
	Sat. 2	62.8		
	Average	65.4	65.0	+ .6

* Periods taken from medical reports.
** Period dates established by estimation.

Period of Test	Date of Sick Period	Average Hourly Output	Average Hourly Output of Complete Test Period	Per Cent + of "Sick Period" Compared to Complete Test Period
No. 10 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest (Continued)	Wed. 6-27-28	61.8		
	Thur. 28	63.7		
	Fri. **29	67.7		
	Sat. 30	68.5		
	Average	65.4	65.0	+ .6
No. 11 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, Saturday A.M. off	Wed. 7-25-28	69.4		
	Thur. 26	68.2		
	Fri. 27	66.4		
	Sat. *28	No Work		
	Sun. 29	Sunday		
	Mon. 30	Vacation		
	Average	68.0	66.6	+ 2.1
	Fri. 8-17-28	61.7		
	Sat. 18	No Work		
	Sun. 19	Sunday		
	Mon. 20	63.0		
	Tue. **21	72.0		
	Wed. 22	70.6		
	Thur. 23	71.9		
	Average	67.8	66.6	+ 1.8
No. 12 - No Lunches, No Rests	Fri. 9-14-28	65.1		
	Sat. 15	61.4		
	Sun. 16	Sunday		
	Mon. 17	63.1		
	Tue. *18	65.1		
	Wed. 19	65.1		
	Thur. 20	61.4		
	Average	63.5	63.5	0

* Periods taken from medical reports.
** Period dates established by estimation.

- Oper. No. 3

Period of Test	Date of Sick Period	Average Hourly Output	Average Hourly Output of Complete Test Period	Per cent + of "Sick Period" Compared to Complete Test Period
No. 10 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest	Mon. 4-23-28	59.5		
	Tue. 24	59.4		
	Wed. 25	58.8		
	Thur. **26	58.6		
	Fri. 27	60.0		
	Sat. 28	57.2		
	Average	58.9	62.1	- 5.2
	Wed. 5-23-28	67.1		
	Thur. 24	64.7		
	Fri. 25	65.6		
	Sat. **26	61.5		
	Sun. 27	Sunday		
	Mon. 28	59.4		
	Average	63.7	62.1	+ 2.6
	Sat. 6-23-28	63.0		
	Sun. 24	Sunday		
	Mon. 25	62.3		
	Tue. *26	64.0		
	Wed. 27	58.3		
	Thur. 28	61.3		
	Average	61.8	62.1	- .5
No. 11 - 15 Min. A.M. Lunch, 10 Min. P.M. Rest, Saturday A.M. off	Sat. 7-21-28	Sat.off		
	Sun. 22	Sunday		
	Mon. 23	61.0		
	Tue. **24	65.9		
	Wed. 25	63.3		
	Thu. 26	63.3		
	Fri. 27	63.0		
	Average	63.3	64.0	- 1.1
	Thu. 8-16-28	67.4		
	Fri. 17	67.5		
	Sat. 18	Sat.off		
	Sun. **19	Sunday		
	Mon. 20	61.7		
	Tue. 21	66.1		
	Wed. 22	65.2		
	Average	65.6	64.0	+ 2.5

*Periods taken from medical reports.
**Period date established by estimation.

Period of Test	Date of Sick Period	Average Hourly Output	Average Hourly Output of Complete Test Period	Per cent ± of "Sick Period" Compared to Complete Test Period
No. 12 - No Lunches, No Rests	Tue. 9-11-28	61.8		
	Wed. 12	63.0		
	Thu. 13	61.5		
	Fri. *14	61.4		
	Sat. 15	65.5		
	Sun. 16	Sunday		
	Mon. 17	59.9		
	Average	62.2	60.0	+ 3.7

*Periods taken from medical reports.

- Oper. No. 4

Period of Test	Date of Sick Period	Average Hourly Output	Average Hourly Output of Complete Test Period	Per cent + of "Sick Period" Compared to Complete Test Period
No. 10 - 15	Mon. 4-16-28	61.5		
Min. A.M.	Tue. 17	58.8		
Lunch, 10 Min.	Wed. 18	63.5		
P.M. Rest	Thu. *19	60.6		
	Fri. 20	62.1		
	Sat. 21	61.3		
	Average	61.3	62.8	- 2.5
	Mon. 5-14-28	63.9		
	Tue. 15	60.8		
	Wed. 16	64.0		
	Thu. *17	61.5		
	Fri. 18	63.8		
	Sat. 19	63.5		
	Average	62.9	62.8	+ .2
	Mon. 6-11-28	62.8		
	Tue. 12	66.0		
	Wed. 13	63.5		
	Thu. *14	63.9		
	Fri. 15	65.9		
	Sat. 16	63.5		
	Average	64.3	62.8	+ 2.4
No. 11 - 15	Mon. 7- 9-28	63.2		
Min. A.M.	Tue. 10	65.5		
Lunch, 10 Min.	Wed. 11	61.2		
P.M. Rest,	Thu. **12	62.4		
Saturday off	Fri. 13	66.3		
	Sat. 14	No Work		
	Average	63.7	63.0	+ 1.1
	Mon. 8- 6-28	Vacation		
	Tue. 7	"		
	Wed. 8	"		
	Thu. *9	"		
	Fri. 10	"		
	Sat. 11	"		
No. 12 - No	Mon. 9- 3-28	Holiday		
Lunches, No	Tue. 4	61.3		
Rests	Wed. 5	62.6		
	Thu. *6	59.7		
	Fri. 7	67.1		
	Sat. 8	63.3		
	Average	62.8	61.6	+ 1.9

*Period taken from medical reports.
**Period date established by estimation.

- Oper. No. 5

Period of Test	Date of Sick Period	Average Hourly Output	Average Hourly Output of Complete Test Period	Per cent ± of "Sick Period" Compared to Complete Test Period
No. 10 - 15	Mon. 4-23-28	55.6		
Min. A.M.	Tue. 24	57.1		
Lunch, 10 Min.	Wed. 25	58.1		
P.M. Rest	Thu. **26	57.3		
	Fri. 27	57.0		
	Sat. 28	57.8		
	Average	57.1	55.2	+ 3.4
	Thu. 5-24-28	51.3		
	Fri. 25	51.2		
	Sat. **26	46.8		
	Sun. 27	Sunday		
	Mon. 28	57.1		
	Tue. 29	52.3		
	Average	51.7	55.2	- 6.3
	Mon. 6-25-28	57.3		
	Tue. 26	58.1		
	Wed. 27	54.8		
	Thu. *28	50.3		
	Fri. 29	51.3		
	Sat. 30	50.3		
	Average	53.7	55.2	- 2.7
No. 11 - 15	Mon. 7-23-28	60.0		
Min. A.M.	Tue. 24	50.7		
Lunch, 10 Min.	Wed. 25	59.5		
P.M. Rest,	Thu. **26	55.8		
Saturday	Fri. 27	55.2		
A.M. off	Sat. 28	No Work		
	Average	56.2	55.1	+ 2.0
	Fri. 8-24-28	59.6		
	Sat. 25	No Work		
	Sun. **26	Sunday		
	Mon. 27	58.0		
	Tue. 28	59.7		
	Wed. 29	58.0		
	Average	58.8	55.1	+ 6.7
No. 12 - No	Mon. 9-24-28	51.5		
Lunches,	Tue. 25	59.4		
No Rests	Wed. 26	58.5		
	Thu. *27	55.8		
	Fri. 28	56.0		
	Sat. 29	52.1		
	Average	55.5	56.3	- 1.4

*Periods taken from medical reports.
**Period date established by estimation.

4. Hours of Sleep in Relation to Output

Is output related to the amount of sleep during the previous night?

In order to answer this question, output for individual operators was plotted against the number of hours of sleep each had the night before. No direct relationship was found. Likewise output was plotted against the number of hours of sleep each had the second night previous without finding any direct relationship. Both high and low outputs were observed following long hours of sleep and following short hours of sleep. Obviously, sleep is not a dominant factor in determining output.

Is sleep a minor factor or of any importance in determining output?

If so, the difference should appear upon averaging the output for a large number of days following short hours of sleep and comparing this figure with the average output for a large number of days following long hours of sleep. In order to secure comparative average data, the output for each operator was recorded by days from March 23, 1928, to November 8, 1929, arranging these output figures in columns according to the length of the sleep time the night before. Each column represented a variation of one hour in sleep. For example, the first column used in the following table reports average output for those days in which the previous night's sleep varied between five hours and six hours. There were a few records in which the amount of sleep was less than five hours and a few records in which it was more than ten hours, but the number of days in these cases was so small that the averages had little significance. The following table and graphs show the effect of sleep upon output for the various operators and for the group as a whole.

It will be seen from the following table and graphs that:

(a) Individual operators vary in their ability to get on with little sleep. For example, operator No. 4 succeeds much better than operator No. 1 when her sleeping period

has been shortened. Operator No. 5 is apparently more affected than any other one in the group by change in the sleep period. (It may be noted from the record that operator No. 1 is a thin, slightly anemic girl. Operator No. 4 is stocky and robust. Operator No. 5 is somewhat older than the other girls and has frequently complained of headache in the past. It is also probable that in her case loss of sleep meant doing extra work in the evening more frequently than with the other girls.

(b) The effect of loss of sleep, when the output for days following five to seven hours of sleep is compared with the output for days following eight to ten hours of sleep, shows a statistically significant difference in the case of operators Nos. 1, 2, and 5. There is an appreciable improvement in the output of operators Nos. 3 and 4 when sleep has been adequate although the difference is not so great as to make it absolutely certain that this difference is not accidental.

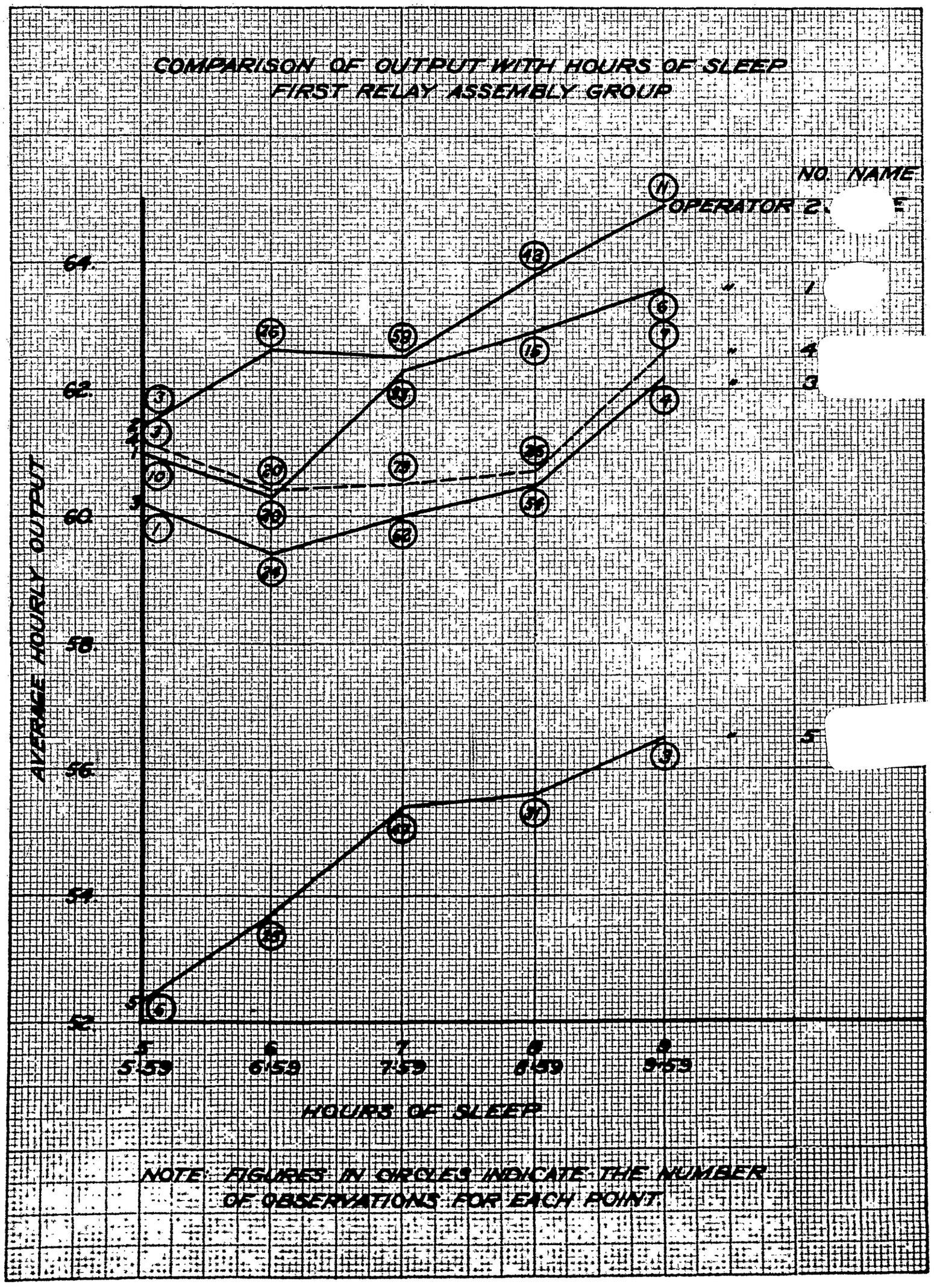
(c) Combining the results for the group as a whole it may be concluded that sleep does have a definite affect upon output. It is a minor factor rather than the direct and preponderant factor. Consequently, some days following a short sleep period may show relatively high output, but on the average an operator or a group of operators produces less when sleep has been between five and seven hours than when it has been between eight and ten hours.

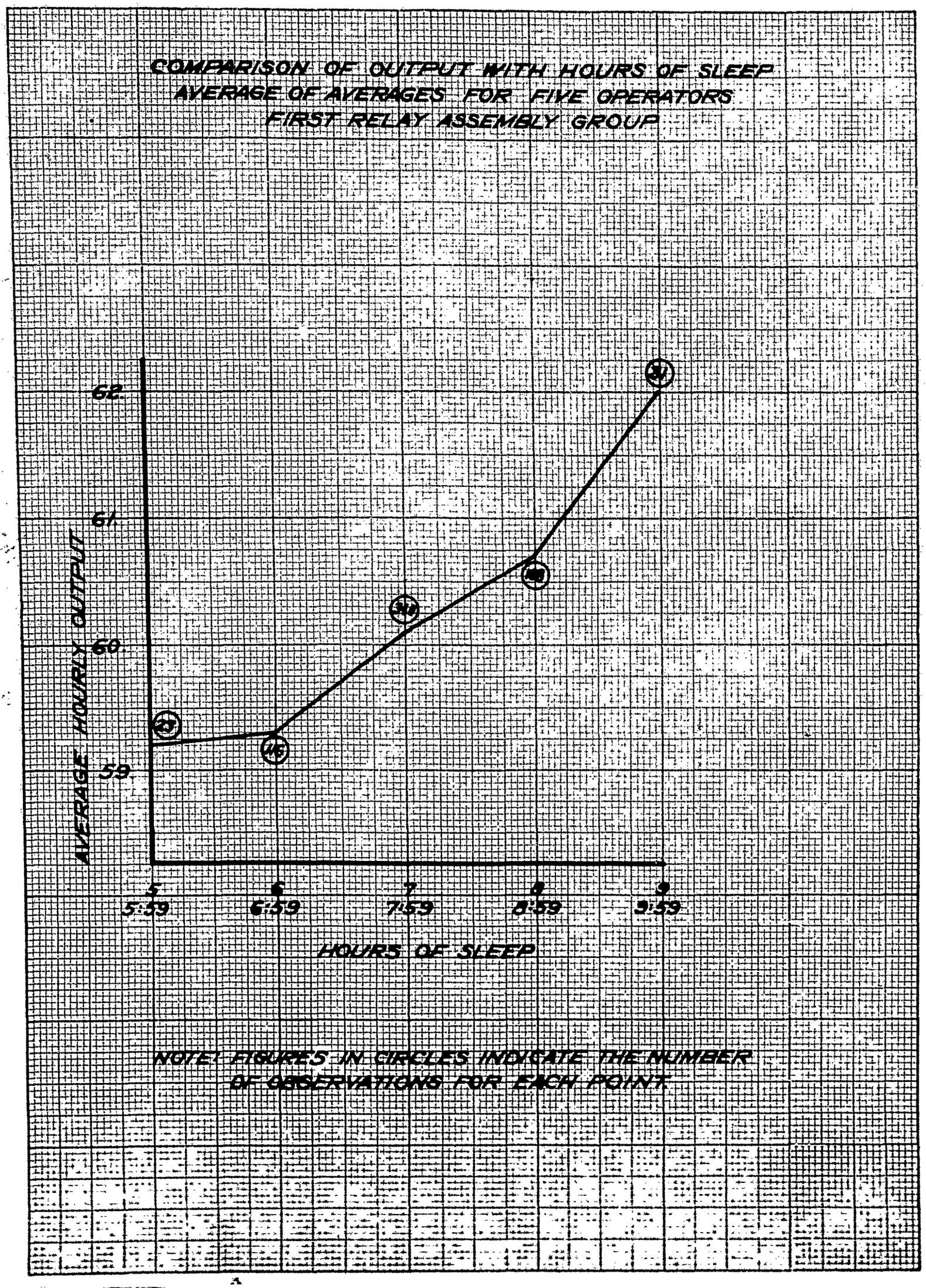
TABLE

AVERAGE OUTPUT IN RELATION TO HOURS OF SLEEP
AND THE STATISTICAL SIGNIFICANCE OF THE DIFFERENCES
FIRST RELAY ASSEMBLY GROUP.

No. Days in Computation	30	21	29	54	25	58	23	32	31	34
Operator	#1		#2		#3		#4		#5	
Hours of Sleep	5 - 7	8 - 10	5 - 7	8 - 10	5 - 7	8 - 10	5 - 7	8 - 10	5 - 7	8 - 10
Average Hourly Output	60.5	63.1	62.5	64.0	59.4	60.6	60.5	61.1	53.5	55.7
Average D^2	145.7	126.6	131.5	335.0	117.3	452.7	65.8	148.6	150.6	170.2
$\sqrt{D^2}$	12.05	11.26	11.45	18.30	10.81	21.27	8.11	12.20	12.27	13.04
P. E.	.2714	.3614	.2667	.2286	.2992	.2474	.2361	.2570	.2670	.2588
P. E. Diff.	.452		.351		.388		.349		.372	
Diff.	2.6		1.5		1.2		0.6		2.2	
D/P.E.Diff.	5.53		4.27		3.09		1.72		5.92	

Note:- See page 40 and following.


COMPARISON OF OUTPUT WITH HOURS OF SLEEP
FIRST RELAY ASSEMBLY GROUP
NO. NAME
OPERATOR 2.
AVERAGE HOURLY OUTPUT
64.
62.
60
58.
56.
54.
52
5:59
6:59
7:59
8:59
9:59
HOURS OF SLEEP
NOTE: FIGURES IN CIRCLES INDICATE THE NUMBER OF OBSERVATIONS FOR EACH POINT.


COMPARISON OF OUTPUT WITH HOURS OF SLEEP
AVERAGE OF AVERAGES FOR FIVE OPERATORS
FIRST RELAY ASSEMBLY GROUP
AVERAGE HOURLY OUTPUT
62
61
60
59
(21)
(46)
(34)
(38)
(37)
5
5:59
6
6:59
7
7:59
8
8:59
9
9:59
HOURS OF SLEEP
NOTE: FIGURES IN CIRCLES INDICATE THE NUMBER OF OBSERVATIONS FOR EACH POINT

B. FATIGUE IN RELATION TO INCREASED OUTPUT - EVIDENCES THAT FATIGUE IS NOT THE PRIMARY FACTOR

During the two years of the test room study there has been a definite upward trend in output. The earnings of the test room operators are distinctly above those in the large gang from which they were taken. Some of the operators are turning out 35% to 50% more work than they were when they came into the test room.

What is the cause of this increased output?

It has generally been assumed that fatigue is a chief limiting cause of output. In fact limitation of output has commonly been used as a definition of fatigue in industrial literature. But such a use of the term fatigue without qualification is confusing. It would make it necessary to include day-dreaming and preoccupation as phases of fatigue.

When the physiologist speaks of fatigue he means neuro-muscular fatigue, that is, the lowered ability to perform muscular work because of the work already done. This lowered working efficiency may be due to tired and over-loaded muscle "engines" or it may be due to fatigue of the nervous system which prevents the deliverance of necessary stimuli to the muscle with proper precision and force. In either case the physiologist assumes a standard mental condition and an optional use of the will. The individual tries his best to do something and is inhibited by a tired neuro-muscular system.

The psychologist on the other hand thinks in terms of the mind. Is the will-to-do always the same? What part in production is played by concentration, preoccupation, or the will to drive one's self to greater efforts? Are there not elements of attitude, personality, will power, contentment and environment which affect output by means of their influence upon the mind of the worker, upon the consciousness or thought control which decides what shall be asked of the neuro-muscular system?

These different approaches to the problem of industrial fatigue explain the confusion of terms in the literature and at the same time indicate the factors which must be considered in interpreting results like those in the test room. These studies upon rest pauses were started with the assumption that brief rests might be of benefit both to the operator and to her output. In the experiment other new things than rest pauses were introduced unavoidably. The supervision, the conditions of work, the size of the gang in which the girls were paid, the operator's relationship

to others, her knowledge of her rate of production and perhaps even other factors were changed.

The first question to be answered in interpreting the data is this: Is the increased production due to a reduction of physiological fatigue or to a changed mental attitude? Is it physiological or psychological? Is the nerve muscle mechanism or the will which drives it the primary apparatus with which the experiment deals?

It is necessary to distinguish clearly between the two contrasting causes of lessened output. On the one hand is fatigue which is defined by Webster as the "condition of cells or organs which have undergone excessive activity with resulting loss of power." On the other hand, is ennui, "a feeling of weariness and dissatisfaction; languor of spirits, arising from satiety or want of interest; tedium."

Obviously both of these conditions exist to some extent among factory operators. Both have an effect upon output. Changes have probably occurred in both under test room conditions. It is believed, however, that improvement in output in test room has been due primarily to a change in the second factor and only secondarily to a change in the first factor. In other words, reduction in neuro-muscular fatigue has not been the primary factor in increasing output.

It is immediately apparent that ennui, which is the opposite of interest, eagerness and incentive, arises from varied causes. Further discussion of this subject will be postponed for the moment in order to present such evidence as has been accumulated showing that cumulative fatigue is not present and that the abatement of fatigue was not the factor primarily involved in increasing output of the test room operators.

1. Changes in Output by Periods

If the changed working conditions in the test room have affected output only through the reduction of muscular fatigue, one would expect to find a direct relationship between output and the various types of rest pauses according to the efficiency of these types of rest pauses in relieving fatigue. Instead one finds, from a study of the output data previously given, a gradual and continually increasing total output which overshadows the variation between various types of rest pauses although in general the speed of production goes up as the working day is shortened.

The increased production during the test has taken the operators from an average weekly output of about 2400 relays at the beginning to a present average weekly output of about 3000 relays. Periods Nos. 7, 10, and 13 had the same working conditions; namely, a fifteen minute rest and lunch in the morning and a ten minute rest in the afternoon. Yet the average weekly output for the group in period No. 7 was a little over 2500 relays, for period No. 10 it was a little over 2800 relays and for period No. 13 it is about 3000 relays. Furthermore, period No, 12 was like period No. 3 in working conditions requiring a full day's work without any lunch or rest. Yet the average output for period No. 3 was less than 2500 relays a week and that for period No. 12 was more than 2900 relays per week. Period No. 12 was continued for twelve weeks and there was no downward trend in the total output. Surely some other factor than relief from muscular fatigue must explain these findings.

The hourly output rate was distinctly higher during the full working day of period No. 12 than during the full working day of period No. 3. Between the comparable periods Nos. 7, 10, and 13 the rate of production also increased.

The gradually rising output indicates the absence of cumulative fatigue. Moreover we find the hourly production rate related to the type of working day more directly than to the length of the working week.

Now period No. 10 retained the lunch and rest, but came back from the four o'clock stop to the five o'clock stop. Hourly output went down somewhat, but total output went up because of the increased working time. Then followed the same type of working day for period No. 11, but with Saturday mornings off, allowing a five day week. The hourly output remained about the same and the decrease in total output was proportional to the shortening of the week. If there had been an appreciable cumulative fatigue it would be expected that the increased period of rest during the week end would have increased the hourly production rate.

The output of the present operators Nos. 1 and 2, who entered the test room at the beginning of the eighth period, as compared with that of operators Nos. 3, 4, and 5, also suggests that one is dealing with something beside muscular fatigue. Operators Nos. 1 and 2 wanted to come into the test room; they knew that two girls had been released and they undoubtedly tried to make a high output record when they first entered the room. No pressure was placed upon them to secure a high output, and they were told that they were to work at their natural speed. At the time the new operators Nos. 1 and 2 joined the group operators Nos. 3, 4, and 5 had increased their efficiency about 20% since the beginning of the

experiment. These new operators produced a higher output than the others from the beginning. They are naturally faster operators. The fluctuation in efficiency for all the operators since that time has been approximately the same. What the output rate for operators Nos. 1 and 2 was in the original department is not known, but it seems likely that they were able to speed up immediately upon coming into the test room, thereby meeting and surpassing the output of operators Nos. 3, 4, and 5 which was then distinctly above that in the gang outside. Certainly their production in the original department was relatively higher in relation to their ability than that of the other three operators. They are now working at 12% to 15% above their initial efficiency in the test room while operators Nos. 3, 4, and 5 are working at 35% to 50% above their base period efficiency. One cannot draw definite conclusions from this experience, but it would seem that, if muscular fatigue were the governing factor, operators Nos. 1 and 2 would have had a lower output rate until they began to secure the benefits of the rest periods or if they had jumped up their production by overwork they would hardly have been able to maintain it.

2. Vascular Skin Reaction Readings as an Index of Fatigue

Procedure:

During the test means have been sought for measuring fatigue. The literature on the physiology of fatigue contains many references to the vascular skin reaction as a fatigue index. It was first discovered by Marey that a white line on the wrist, produced by a pressure which presses together the walls of the blood vessels, disappears more quickly under conditions of fatigue than under conditions of rest. This principle was further studies by Ryan who devised an instrument to be drawn across the wrist in making the white line. Ryan relied upon the extension of a coil spring over a given distance and the skill of the operator in moving the instrument at a uniform rate to give the same pressure conditions on the forearm. In spite of many references confirming Marey's discovery, no data has been found which gives the actual individual readings.

The freedom of this test from influence by the voluntary control of the operator and the simplicity of the procedure made it seem worth while to attempt experimentation to see whether it could be used as a measure of fatigue in factory operations of the type we being studied.

Professor Turner devised a new instrument for producing uniform pressure on the arm. This consists of a rod hinged at one end and with a weight at the other. This rod, the lower edge of which is formed into a round surface of desirable width and curvature, is dropped from a given distance each time the test is made. As the rod is briskly lifted from the wrist a stop watch is started and the time the white line remains discernible on the wrist is recorded to the nearest tenth of a second.

The disappearance of this white line is not easy to read and by studying different types of lighting it was found that it could be read more easily when a purple light was cast upon the arm. The type of light was secured by means of a Cooper Hewitt light with a standard C blue filter such as is used for photographic purposes. This modification of lighting makes it easier to determine the end point which is the complete disappearance of the white line and thereby gives a somewhat longer reading.

In spite of these two improvements in the method of making vascular skin reaction readings the individual successive readings varied widely. These readings commonly varied by 25% and occasionally the lowest reading would not be more than 50% of the highest reading. These variations are apparently due to the subjective difficulties of determining when the end point is reached and of operating the stop watch.

One set of five readings was made thirty minutes after starting work in the morning. Thirty minutes before closing time at night a similar set of readings was made. Following this the operative fatigued the muscles of the hand and lower arm by a series of movements which grip the fingers of the hand tightly and then straighten them back completely. Following this local fatigue a second series of five readings was made.

Computations and Results:

Averages of all morning readings and of both sets of afternoon readings were made for each operator and for the group, over a seven week period. The probable errors of these averages were computed and also the relationship between the differences of the averages and the probable error of these differences. As the tables show, the grand average of the morning reading was 1.71 seconds. That of the afternoon reading was 1.35 seconds and that of the fatigue reading 1.00 seconds. The examination of probable errors shows that these differences are statistically significant. The results confirm the statements previously made that there is a

difference in the speed with which the walls of the minute blood vessels return to their normal shape following pressure, according to the fatigue condition of the worker.

The above results are general and this test cannot be of great use to industry unless it is sufficiently exact to record slight differences in fatigue. The attempts to discover any consistent relationship between these readings and daily variations in output have been entirely unsuccessful. Furthermore, the variations in any particular set of readings makes it clear that minor variations in the extent of fatigue cannot be thus determined.

Conclusions:

(a) The vascular skin reaction does not measure minor differences in the fatigue level. It does show that some fatigue is developed during the day.

(b) The development of a new and better instrument and the discovery of the value of special lighting (monochromatic rather than diffuse) are definite improvements in the technique but do not make consistent readings possible.

(c) The present variation in individual readings is probably due to the subjective element, that is, the difficulty of the observer in determining the end point and accurately recording it by the manipulation of a stop watch.

(d) Until this variation can be eliminated and greater precision obtained the test will not be of value in determining such minor differences of fatigue as are likely to result from slight differences in hours of work.

(e) The use of the motion picture camera or the photo-electric cell may standardize this procedure and increase the reliability and consistency of the readings. The development of these refinements of method is not in the main line of experimentation of this study; and further research in this subject is discontinued at Hawthorne and is being carried on by Professor Turner at the Department of Biology and Public Health of the Massachusetts Institute of Technology.

(f) Local fatigue of hand and wrist muscles following a brief period of vigorous work reduces the vascular skin reaction reading as much as it is reduced by the work of the day.

TABLE
VASCULAR SKIN REACTION READENGS
FIRST RELAY ASSEMBLY GROUP
Weekly Averages of Operators, Period No. 11*

Date of Week	Average A.M. Reading	Average P.M. Reading	Average Fatigue Reading	Av. Diff. Between A.M. & P. M.	P.E. of Difference	Diff.** P.E.Diff.
			Operator No. 1			
7- 2	1.43 sec.	1.05 sec.	.88 sec.	.38 sec.	.0310	12.25
7- 9	1.62	1.23	1.05	.39	.0608	6.42
7-16	1.58	1.32	--	.26	.0460	5.65
7-23	1.64	1.32	--	.32	.0469	6.81
8-13	1.81	1.52	--	.29	.0565	5.13
8-20	1.92	1.39	--	.53	.0517	10.28
8-27	1.69	1.39	--	.30	.0494	6.07
Average	1.68	1.33	.96	.35	.2011	16.6
			Operator No. 2			
7- 2	1.61	1.13	1.13	.48	.0477	10.07
7- 9	1.54	1.24	1.15	.30	.0417	7.20
7-16	1.57	1.27	--	.30	.0500	6.00
7-23	1.75	1.25	--	.50	.0371	13.50
8-13	1.96	1.60	--	.36	.0432	8.35
8-20	2.02	1.52	--	.30	.0475	10.52
8-27	2.03	1.45	--	.58	.0405	14.32
Average	1.79	1.36	1.14	.43	.0213	20.2
			Operator No. 3			
7- 2	1.50	1.10	.86	.40	.0354	11.30
7- 9	1.47	1.26	.96	.21	.0576	3.65
7-16	1.36	1.19	--	.17	.0433	3.92
7-23	1.55	1.25	--	.30	.0492	6.10
8-13	1.76	1.49	--	.27	.0487	5.54
8-20	1.90	1.40	--	.50	.0583	8.98
8-27	1.74	1.44	--	.30	.0432	6.95
Average	1.62	1.31	.91	.31	.0217	14.3
			Operator No. 4			
7- 2	1.52	1.14	.89	.38	.0345	11.00
7- 9	1.59	1.12	.99	.47	.0492	9.55
7-16	1.42	1.23	--	.19	.0464	4.10
7-23	1.48	1.28	--	.20	.0506	3.95
8-13	1.76	1.53	--	.23	.0631	3.64
8-20	1.92	1.52	--	.40	.0647	6.18
8-27	1.89	1.45	--	.44	.0596	7.39
Average	1.66	1.34	.94	.32	.0243	13.2

* 15 min. A.M. lunch, 10 min. P.M. rest, Sat. A.M. off.
** See page 40 and following.

Date of Week	Average A.M. Reading	Average P.M. Reading	Average Fatigue Reading	Av. Diff. Between A.M. & P. M.	P.E. of Difference	Diff. / P.E.Diff.
			Operator No. 5			
7- 2	1.72	1.22	1.03	.50	.0603	8.30
7- 9	1.56	1.45	1.09	.11	.0696	1.58
7-16	1.44	1.25	--	.19	.0421	4.51
7-23	1.59	1.27	--	.32	.0408	7.84
8-13	2.20	1.57	--	.63	.0575	10.95
8-20	2.07	1.64	--	.43	.0576	7.46
8-27	2.08	1.60	--	.48	.0725	8.62
Average	1.81	1.43	1.06	.38	.0275	13.8
			Layout Operator No. 6			
7- 2	1.70	1.48	1.27	.22	.0603	3.64
7- 9	1.80	1.52	1.21	.28	.0769	3.64
7-16	1.86	1.36	--	.50	.0409	12.20
7-23	1.80	1.32	--	.48	.0496	9.68
8-13	1.97	1.68	--	.29	.0426	6.80
8-20	2.17	1.64	--	.53	.0634	8.37
8-27	1.90	1.68	--	.22	.0460	4.78
Average	1.89	1.53	1.24	.46	.0229	20.1

RECAPITULATION OF AVERAGES

Oper. No.	Name	Average A.M. Reading	Average P.M. Reading	Average Fatigue Reading	Av. Diff. Between A.M. & P.M.	P.E. of Difference	Diff. / P.E. Diff.
1		1.68 sec.	1.33 sec.	.96 sec.	.35 sec.	.0211	16.6
2		1.79	1.36	1.14	.43	.0213	20.2
3		a1.62	1.31	.91	.31	.0217	14.3
4		1.66	1.34	.94	.32	.0243	13.2
5		1.81	1.43	1.06	.38	.0275	13.8
All five		1.71	1.35	1.00	.36	.0104	34.6

3. Output by Days of the Week

The output studies by days of the week indicate that cumulative muscular fatigue is not present. The output is characteristically low on Mondays and Saturdays and is maintained at a high level during the other four days of the week. The low Monday output is not due to a warming-up period following Sunday rest because several individual operators show occasional Mondays upon which the output is the highest for the week. It is not likely that the low output on Saturday is due to comulative fatigue since during last December the Saturday output came up to a level of that for the other days while the Monday output did not correspondingly increase.

4. Health of Operators

The physical examinations indicate the complete maintenance of health of assembly operators. The girls say that they feel better and enjoy their work more than at any time since they have been employed. These girls were all experienced operators prior to the test and yet their output for period No. 12 is 35% greater than that for the similar period No. 3. In period No. 12 there were no rest pauses to provide relaxation and the maintenance of improved output with the maintenance of health would indicate that there are some factors other than muscular fatigue responsible for the improvement in production, and that the individual is not working at a pace which she could not maintain continuously.

5. Periodic Illness

It seems likely that, if this type of work were accompanied by serious muscular or nervous fatigue, there would be a reduction in output during periods of monthly illness.

6. Sleep and Output

The amount of fatigue produced in connection with extensive reductions in the amount of sleep has a minor effect upon output for the following day.

7. Blood Pressure Findings

The blood pressure readings for operators in this group indicate that the girls are working well within their capacity throughout the day. It will be recalled that fatigue as indicated by cardio-vascular indices is less in this group than in the other groups of workers tested by Dr. Mayo.

C. FACTORS OTHER THAN FATIGUE

Now that there is reason to believe that changed attitude or relief from ennui rather than from muscular fatigue has primarily effected the change in rate of production in this type of process, the problem is to analyze further the factors involved. Were the operators not trying to make the highest possible production while in the regular department? Have the conditions of the test merely taken away the opportunity for individual output control? How large a factor was payment on the small gang basis? Has there been developed here a process of training which led to new "habits of work"? Is preoccupation an important factor in limiting output? What is the relative importance of improved conditions and which improvements are of greatest value?

There are several factors which affect the ability of the individual to give continuous and satisfactory application to the work in hand. These factors must be considered in analyzing the results.

To enumerate:

1. Contentment

Greater contentment has been reflected in the desire of the operators to remain in the test room rather than to go back to the large gang outside. It has been further reflected in the tremendous drop in absenteeism. There is no doubt from their statements that there was some discontent prior to coming into the test room group and the apparent success of the interviewing plan* which has arisen out of this study further bears out the important relationship between satisfactory supervision and morale. It is believed that this factor is important but as yet it cannot be given an exact relative value.

2. Changed Habits of Work

The operators were afraid to increase the length of the rest pauses beyond five minutes because they thought they would lose money since they would probably be unable to make up for the time lost. That feeling on their part is believed to have been sincere. There has been a great increase in the speed of production and in total output which means sustained production at a higher speed. To what extent can this have been due to a training process like that which the athletes go through? These operators have frequently been urged not to "speed" but they have, at the same time, been able to see their production day by day and there is always a stimulus for one to improve his former record.

* See Section V, Part A, Item 2.

3. Preoccupation and Concentration

These factors are directly related to contentment, they are also related to home conditions and outside activities. There is some relationship between health and these mental conditions. Improved concentration may be also the result of mental training. These things are separate from the mere skill which arises from training, however. These factors may directly affect output. At the same time they are affected by other conditions.

4. Earnings

To what extent was the opportunity for each girl to have more nearly what she earned, because of working in a small gang, a factor in increasing her output?

5. Working Conditions

The aim was to make little change in working conditions in addition to those the effects of which it was desired to study. Nevertheless, the girls were in a room by themselves. They were free to converse with each other within limits and there was beside each desk a slot through which each completed relay slipped with a clipping sound. Some of these conditions may have had an effect upon output.

6. Pacing each other

It has been noted that operators Nos. 1 and 2 tend to work in unison and that operators Nos. 3 and 4 do the same thing to some extent. It may be that close association, conversation, and the opportunity to observe the output of the adjacent operator more easily (because of the recording device) has had the effect of keeping operators in step at a quickened pace.

Efforts are being made to determine the relative importance of some of these factors by specially designed experiments, the inception of which is reported in the following section. It is unlikely that any one factor will be found which is primarily responsible for the result obtained, but if the studies are to be of greatest use industrially they should determine as well as possible the relative values of these different possible causes.

SECTION IV

NEW STUDIES

A. SECOND RELAY ASSEMBLY GROUP

On August 27, 1928, a special test was started to determine the importance of being paid in a small gang as a factor in increasing output. The desire was to simulate the change made in the test room in only one respect; namely, that of the method of payment. Five operators in the relay assembly department were selected and their outputs determined in terms of the number of piece parts assembled. For a period of five weeks a record was kept of their outputs without their knowing it. These outputs were averaged for use as a 100% or base period figure. (Data for operators Nos. 1 and 2 were not secured for the full five week period.)

At the end of this base period the girls were told that they were to be formed into a special small gang of five and that this small gang would be paid separately. These operators were left at their same benches with the same supervision and the same working conditions. The significant difference between the base period and the special gang period was the difference in the method of payment. Perhaps it should be kept in mind also that these operators knew that their individual outputs were being carefully measured under the special gang arrangement.

This second period of work (special gang period) was continued for nine weeks. At the end of that time considerations outside the experimental program made it desirable to return these girls to their regular groups. Their output records were kept for a time after they went back to the regular gang and these records constitute the third or another regular gang period of the experiment.

There was, then, a base period for these girls under regular working conditions, a special gang period in which the gang of five was paid separately, and a third or regular gang period after they had returned to the original working conditions. On the following pages are presented (1) the basic output data, (2) table No. 1 giving the weekly average hourly output and the percentage of efficiency, and (3) table No. 3 giving the total weekly output by the periods of the test. By the end of the seventh week after the girls had been returned to the regular gang all of the operators except one had been transferred to other classes of work. The keeping of records was, therefore, discontinued and this special test brought to an end.

1. Results.

The first week after placing the five operators on a special gang basis so far as pay was concerned, the average output for the group increased 13.8%. This average output remained from 10% to 15% above that of the base period throughout the nine weeks of the special gang period. Upon the return to the regular gang the average output for the group dropped to 94.8% of the output for the base period. The output did not come back to that of the base period and for one week, the fifth, it was only 89.6% of the output for the base period.

The output for individual operators varied widely. It will be noticed that operator No. 3 increased her output 25% during the first week of the special gang period. The other four operators improved from 8% to 15% in output during this first week. Conversely upon return to the regular gang period operator No. 3 showed an output during the first week which was only 60.6% of her base period production, a little more than half what it was for the week before. It was the reduction in output of this operator which accounted chiefly for the drop in the week's average since operator No. 1 produced 90% of her base period output and operators Nos. 2 and 4 were 16.5% and 14.6% above the base period respectively. Operator No. 5 was absent.

The increase in output of this group was more prompt and more extensive than that for the test room group when they went on a special gang rate. It may be, of course, that the knowledge that their individual output would be more carefully scrutinized and the suspicion that some experiment was under way stimulated this increased output. Nevertheless, it seems fair to conclude that the basis of pay has been an important item in increasing output in the test room. It seems likely from this experience that an increased output is to be expected when a large gang is broken up into small groups for purposes of payment.

The following tables viz; basic data, table No. 1 and table No. 3 are of this second assembly group.

These data are shown in numbers of piece parts which go to make up the relays and not by numbers of relays.

BASIC DATA TABLE FOR SECOND RELAY ASSEMBLY GROUP*
Daily Output in Terms of Piece Parts

Date	Hrs. & Min. Worked	Operators 1	2	3	4	5	Av. for Group
PERIOD NO. 1 - BASE PERIOD IN REGULAR GANG							
8-27-28	8:20	On other work		On other work		14,481	12,910		14,776
8-28	8:20	" " "	" " "		12,627	12,980		14,771
8-29	8:20	" " "	" " "		"13,612"	12,548		"14,337"
8-30	8:20	" " "	" " "		14,380	13,412		13,751
8-31	8:20	" " "	" " "		13,758	14,014		14,109
9- 1	4:00	" " "	" " "	(12,447)	5,977	(14,594)	7,008	(14,244)	6,840
TOTAL	45:40	" " "	" " "		74,835		72,872		75,584
9- 3	8:20	" " "	" " "		"14,403"		"13,131"		"14,423"
9- 4	8:20	" " "	" " "		13,760		13,537		14,224
9- 5	8:20	" " "	" " "		13,738		11,410		14,880
9- 6	8:20	" " "	" " "		14,646		13,626		14,523
9- 7	8:20	" " "	" " "		15,201		13,646		14,419
9- 8	4:00	" " "	" " "	(15,001)	7,203	(13,796)	6,625		6,587
TOTAL	45:40	" " "	" " "		78,951		71,975		79,056
9-10	8:20	" " "	" " "		15,093		13,553		14,607
9-11	8:20	" " "	" " "		15,187		13,483		14,288
9-12	8:20	" " "	" " "		14,416		12,900		14,248
9-13	8:20	" " "	" " "		"14,922"		12,057		14,622
9-14	8:20	" " "	" " "		15,276		13,613		14,377
9-15	4:00	" " "	" " "	(14,369)	6,900	(13,909)	6,679	(13,688)	6,573
TOTAL	45:40	" " "	" " "		81,794		72,285		78,715

*Refer to explanation at beginning of Basic Data Table for First Relay Assembly Group, page No. 6.

Date	Hrs. & Min. Worked	Operators 1		2		3		4		5		Av.for Group
9-17	8:20	"13,648"		On other work		15,785		13,435		15,010		
9-18	8:20	12,110		" " "		15,338		12,647		15,028		
9-19	8:20	13,037		" " "		15,241		13,435		15,001		
9-20	8:20	14,026		" " "		15,226		14,151		14,744		
9-21	8:20	13,660		" " "		14,587		12,897		13,476		
9-22	4:00	8,330	(17,347)	" " "	(13,635)	6,508	(13,153)	6,316	(14,594)	7,008		
TOTAL	45:40	74,811		" " "		82,685		72,881		80,267		
9-24	8:20	13,430		12,553		14,782		14,025		15,228		
9-25	8:20	14,283		12,144		14,892		13,116		15,176		
9-26	8:20	13,275		13,050		14,190		13,055		15,049		
9-27	8:20	12,839		12,553		14,468		11,933		15,046		
9-28	8:20	12,515		11,966		14,849		13,209		14,889		
9-29	4:00	6,014	(12,524)	5,522	(11,500)	6,677	(13,904)	6,112	(12,728)	6,568	(13,678)	
TOTAL	45:40	72,356		67,788		79,858		71,450		81,956		
PERIOD	228:20*	147,167		67,788		398,123		361,463		398,578		
AV. HR. OUTPUT		1,611		1,484		1,743		1,583		1,745		1,633

PERIOD NO. 2 - SPECIAL GANG RATE

11-26	8:20	14,843		15,023		18,460		14,094		16,000		15,684
11-27	8:20	15,390		15,000		18,970		15,034		16,184		16,116
11-28	8:20	13,523		14,032		17,817		15,018		15,340		15,146
11-29	8:20	"14,603"		"14,273"		"18,164"		"14,689"		"15,703"		"15,486"
11-30	8:20	14,559		13,261		16,849		15,244		15,658		15,114
12-1	4:00	7,129	(14,847)	6,648	(13,844)	9,303	(19,374)	6,438	(13,407)	7,190	(14,973)	7,342 (15,290)
TOTAL	45:40	80,047		78,237		99,563		80,517		86,075		84,888

*91:20 for Operator No. 1
45:40 for Operator No. 2

Date	Hrs. & Min. Worked	Operators 1	2	3	4	5	Av.for Group
12-3	8:20		14,715	14,083	18,326	15,179	15,649	15,590
12-4	8:20		15,502	15,149	18,624	15,800	16,146	16,244
12-5	8:20		13,341	13,283	18,141	15,125	15,008	14,980
12-6	8:20		14,351	13,110	16,060	15,784	15,551	14,971
12-7	8:20		14,133	14,301	17,184	15,073	15,803	15,299
12-8	4:00	("14,402")	"6,916" (13,632)	6,546 (16,860)	8,096 (14,797)	7,105 (14,590)	7,006 (14,856)	7,134
TOTAL	45:40		78,958	76,472	96,431	84,066	85,163	84,218
12-10	8:20		13,696	15,310	17,201	15,294	15,791	15,458
12-11	8:20		14,810	14,097	19,365	15,261	16,009	15,908
12-12	8:20		15,151	14,035	17,654	15,076	16,005	15,584
12-13	8:20		15,255	15,419	17,598	15,061	16,051	15,877
12-14	8:20		14,020	14,427	18,705	15,013	16,031	15,639
12-15	4:00	(13,940)	6,694 (14,290)	6,862 (16,752)	8,044 (15,217)	7,307 (15,571)	7,585 (15,154)	7,298
TOTAL	45:40		79,626	80,150	98,567	83,012	87,472	85,764
12-17	*8:20		13,900	13,682	16,986	15,281	"15,862"	15,142
12-18	8:20		14,907	14,475	16,967	15,542	15,366	15,451
12-19	8:20		15,000	15,014	17,016	16,020	16,151	15,840
12-20	8:20		14,072	13,542	17,494	15,637	15,503	15,250
12-21	8:20		13,894	13,563	19,276	14,772	16,321	15,565
12-22	4:00	(14,159)	6,799 (12,527)	6,015 (17,008)	8,167 (14,934)	7,171 (16,121)	7,741 (14,950)	7,179
TOTAL	45:40		78,572	76,291	95,906	84,423	86,944	84,427
12-24	8:20		13,363	14,532	15,281	15,166	14,391	14,547
12-25	8:20		"13,735"	"14,244"	"16,249"	"15,234"	"15,304"	"14,953"
12-26	8:20		13,735	14,069	15,864	15,019	15,009	14,739
12-27	8:20		12,902	13,158	16,209	15,318	15,711	14,660
12-28	8:20		14,958	15,235	17,663	15,450	16,122	15,886
12-29	4:00	(13,735)	"6,596" (14,244)	"6,840" (16,249)	"7,803" (15,234)	"7,315" (15,304)	"7,349" (14,953)	"7,181"
TOTAL	45:40		75,289	78,078	89,069	83,502	83,886	81,966

*Overtime of one hour four days per week started here.

Date	Hrs. & Min. Worked	Operators 1		2		3		4		5		Av.for Group
12-31	8:20	15,597		12,955		16,358		14,453		16,251		15,123
1-1-29	8:20	"14,291"		"14,139"		"16,473"		"15,207"		"16,009"		"15,224"
1-2	8:20	13,449		15,351		17,229		15,699		16,686		15,683
1-3	8:20	13,804		14,603		16,234		15,496		16,303		15,288
1-4	8:20	14,141		13,450		16,109		15,182		15,923		14,961
1-5	4:00	7,052	(14,684)	7,001	(14,579)	7,894	(16,438)	7,320	(15,243)	6,581	(13,705)	7,170 (14,930)
TOTAL	45:40	78,334		77,499		90,297		83,357		87,753		83,449
1-7	8:20	12,778		14,286		17,928		15,438		15,340		15,154
1-8	8:20	16,124		14,614		17,905		14,349		14,463		15,491
1-9	8:20	15,023		15,079		18,227		15,359		16,016		15,941
1-10	8:20	14,126		13,909		17,141		14,728		13,600		14,701
1-11	8:20	14,502		13,398		15,868		14,726		17,802		15,259
1-12	4:00	6,643	(13,834)	6,761	(14,079)	"8,358"	(17,406)	"7,161"	(14,913)	7,645	(15,291)	7,314 (15,105)
TOTAL	45:40	79,196		78,047		95,427		81,761		84,866		83,860
1-14	8:20	"14,107"		11,677		15,425		14,438		15,495		14,228
1-15	8:20	13,212		13,492		16,315		15,180		15,530		14,746
1-16	8:20	14,440		14,302		16,730		14,744		15,371		15,117
1-17	8:20	14,091		14,301		17,100		16,235		16,703		15,686
1-18	8:20	14,909		15,533		16,759		15,612		15,356		15,634
1-19	4:00	6,565	(13,671)	7,000	14,577	8,030	16,723	7,296	15,194	7,815	16,274	7,341 15,288
TOTAL	45:40	77,324		76,305		90,359		83,505		86,270		82,752
1-21	8:20	14,457		14,743		16,582		15,203		15,178		15,233
1-22	8:20	13,655		14,701		15,264		14,346		Abs.		14,492
1-23	8:20	14,231		14,510		16,107		14,576		Abs.		14,856
1-24	8:20	15,030		14,300		15,496		13,871		Abs.		14,674
1-25	8:20	14,538		14,319		16,978		14,700		Abs.		15,134
1-26	4:00	7,099	(14,784)	6,808	(14,177	7,809	(16,263)	6,952	(14,478)	Abs.	14,926	7,167
TOTAL	45:40	79,010		79,381		88,236		79,648		Abs.		81,556
PERIOD	411:00	706,356		700,460		843,855		743,791				752,880
AV.HR.OTUPUT		1719		1704		2053		1810				1831

PERIOD NO. 3 - RETURN TO REGULAR GANG

Date	Hrs. & Min. Worked	Operators 1		2		3		4		5		Av.for Group
1-28	8:20			13,570		14,895		8,598		15,589		13,163
1-29	8:20			13,749		15,406		8,911		13,874		12,985
1-30	8:20			12,600		14,689		8,923		15,498		12,928
1-31	8:20			13,749		14,671		8,740		15,203		13,091
2-1	8:20			12,793		13,031		9,027		15,508		12,590
2-2	4:00	(13,286)		"6,380"	(13,126)	6,303		4,075	(14,994)	7,200		5,990
TOTAL	45:40			72,841		78,995		48,274		82,872		70,747
Abs.			(12,473)									

Note: Operator No. 3 handling "small lots" all of this week.

2-4	8:20			"13,750"		15,312		8,750		15,335		13,287
2-5	8:20			12,074		15,625		10,193		15,625		13,379
2-6	8:20			14,420		15,000		8,512		15,564		13,374
2-7	8:20			14,296		14,866		9,147		15,258		13,392
2-8	8:20			14,029		14,713		8,344		15,153		13,060
2-9	4:00	(14,161)		6,800	(12,995)	6,240	(7,930)	3,808	(15,098)	7,250		6,025
TOTAL	45:40			75,369		81,756		48,754		84,185		72,517
Abs.			(12,546)									

2-11	8:20			13,904		14,309		9,738		15,044		13,249
2-12	8:20			13,405		14,280		9,104		15,159		12,987
2-13	8:20			14,347		14,059		8,325		15,232		13,041
2-14	8:20			13,580		14,798		10,494		15,360		13,558
2-15	8:20			13,472		14,153		10,073		14,564		13,066
2-16	4:00	(12,647)		6,073	(12,717)	6,107	(9,350)	4,490	(14,728)	7,072	(13,365)	6,032
TOTAL	45:40			74,781		77,706		52,424		82,431		71,933
Abs.			(12,561)									

2-18	8:20			12,506		13,071		8,792		14,785	Transferred	12,289
2-19	8:20			13,660		13,816		11,011		14,785	"	13,318
2-20	8:20			11,430		14,000		9,361		15,010	"	12,450
2-21	8:20			"12,682"		12,771		9,156		14,879	"	12,372
2-22	8:20			13,787		11,625		9,046		14,568	"	12,257
2-23	4:00	(11,350)		5,450	(12,974)	6,230	(8,258)	3,965	(14,588)	7,005	"	5,663
TOTAL	45:40			69,515		71,513		51,331		81,032	"	68,349
			(11,973)									

Date	Hrs. & Min. Worked	Operators 1	2	3	4	5	Av.for Group
2-25	8:20	13,086	13,151	9,615	11,630	Transferred	11,871
2-26	8:20	12,370	11,562	9,149	14,357	"	11,860
2-27	8:20	13,214	13,340	9,610	14,702	"	12,742
2-28	8:20	13,064	12,944	9,181	14,892	"	12,520
3-1	8:20	12,656	12,879	10,087	13,549	"	12,293
3-2	4:00	6,235 (10,519)	5,075 (8,466)	4,065 (14,133)	6,786	" (11,538)	5,540
TOTAL	45:40	70,625	68,951	51,707	75,916	"	66,826
3-4	8:20	"12,567"	"12,732"	11,621	14,866	"	12,947
3-5	8:20	13,056	12,476	12,747	14,883	"	13,291
3-6	8:20	12,485	12,245	11,251	14,400	"	12,595
3-7	8:20	11,819	11,716	Transferred	14,463	"	12,666
3-8	8:20	12,458	13,687	"	14,769	"	13,638
3-9	4:00 (13,536)	6,500 (14,432)	6,930	" (14,578)	7,000	" (14,182)	6,810
TOTAL	45:40	68,845	69,786	"	80,381	"	71,947
3-11	8:20	12,517	11,901	Abs.	14,991	"	13,136
3-12	8:20	12,956	11,939	Transferred	14,856	"	13,250
3-13	8:20	Transferred	11,902	"	15,144	"	13,523
3-14	8:20	"	Transferred	"	13,824	"	13,824
3-15	8:20	"	"	"	15,196	"	15,196
3-16	4:00	"	"	"	7,400 (15,411)	"	7,400
TOTAL	45:40	"	"	"	81,411	"	76,329
PERIOD	319:40				568,228		498,648
AV.HR.CUTPUT					1,781		1,560

END OF TEST

TABLE NO. 1
SECOND RELAY ASSEMBLY GROUP
Average Hourly Output and Percent of Efficiency by Weeks and By Periods

The base period group average is equal to the average of the individual averages and not an average of totals, as base periods of individual operators were of different lengths.

Period	No. of Wk. in Period	Hrs. of Work Per Wk.	Opr. No. 1 Aver. Hourly Output	Opr. No. 1 % of Eff.	Opr. No. 2 Aver. Hourly Output	Opr. No. 2 % of Eff.	Opr. No. 3 Aver. Hourly Output	Opr. No. 3 % of Eff.	Opr. No. 4 Aver. Hourly Output	Opr. No. 4 % of Eff.	Opr. No. 5 Aver. Hourly Output	Opr. No. 5 % of Eff.	Group Aver. Hourly Output	Group % of Eff.
No. 1	1	45.67					1638.4	94.0	1595.6	100.0	1722.9	98.7		
Base Period	2						1728.1	99.1	1576.0	99.6	1731.0	99.1		
in Regular	3						1791.0	102.7	1582.8	100.0	1723.5	98.7		
Gang	4		1638.2	101.7			1814.9	104.1	1595.8	100.8	1757.5	100.7		
	5		1584.5	98.3	1484.3	100	1748.6	100.3	1564.5	98.8	1794.5	102.8		
	AVER.		1611.4	100	1484.3	100	1743.6	100	1583.1	100	1745.6	100	1633.6	100
No. 2	1	45.67	1752.9	108.8	1713.1	115.4	2180.1	125.0	1763.0	111.4	1884.7	108.0	1858.7	113.8
Special	2		1728.9	107.3	1674.4	112.8	2111.5	121.1	1840.7	116.3	1864.7	106.8	1844.1	112.9
Gang Rates	3		1743.5	108.2	1755.0	118.2	2158.2	123.8	1817.6	114.8	1915.3	109.7	1877.9	115.0
	4		1720.4	106.8	1670.5	112.5	2100.0	120.4	1848.5	116.8	1903.7	109.1	1848.6	113.2
	5		1648.5	102.3	1709.6	115.2	1950.3	111.9	1828.4	115.5	1836.8	105.2	1794.7	109.9
	6		1715.3	106.4	1696.9	114.3	1977.2	113.4	1825.2	115.3	1921.5	110.1	1827.2	111.9
	7		1734.1	107.6	1708.9	115.1	2089.5	119.8	1790.3	113.1	1858.7	106.5	1836.2	112.4
	8		1693.1	105.1	1670.8	112.6	1978.5	113.5	1828.4	115.5	1889.0	108.2	1812.0	110.9
	9		1730.0	107.4	1738.1	117.1	1932.0	110.8	1744.0	110.2	Abs.		1785.8	109.3
	AVER.		1718.5	106.7	1704.1	114.8	2053.0	117.7	1809.6	114.3	1884.3	107.9	1831.7	112.1

Period	No. of Wk. in Period	Hrs. of Work Per Wk.	Opr. No. 1 Aver. Hourly Output	Opr. No. 1 % of Eff.	Opr. No. 2 Aver. Hourly Output	Opr. No. 2 % of Eff.	Opr. No. 3 Aver. Hourly Output	Opr. No. 3 % of Eff.	Opr. No. 4 Aver. Hourly Output	Opr. No. 4 % of Eff.	Opr. No. 5 Aver. Hourly Output	Opr. No. 5 % of Eff.	Group Aver. Hourly Output	Group % of Eff.
No. 3	1	45.67	1594.9	99.0	1729.7	116.5	1057.0	60.6	1814.6	114.6	Abs.		1549.1	94.8
Return to	2		1650.3	102.4	1790.1	120.6	1067.5	61.2	1843.3	116.4	Abs.		1587.8	97.2
Regular	3		1637.4	101.6	1701.5	114.6	1147.9	65.8	1804.9	114.0	Abs.		1575.1	96.4
Gang	4		1522.1	94.5	1565.9	105.5	1124.0	64.5	1774.3	112.1	Transferred		1496.6	91.6
	5		1546.4	96.0	1509.8	101.7	1132.2	64.9	1662.3	105.0	"		1463.2	89.6
	6		1508.3	93.6	1528.0	102.9	Transferred		1760.0	111.2	"		1575.4	96.4
	7		Transferred		Transferred		"		1782.6	112.6	"		-	

END OF TEST

TABLE NO. 3
SECOND RELAY ASSEMBLY GROUP
Total Weekly Output and Average Weekly Output by Periods of Test

The base period group average is equal to the average of the individual averages and not an average of totals, as base periods of individual operators were of different lengths.

Period	Week	Hrs. of Work Per Wk.	Oper. No. 1 Total Weekly Output	Oper. No. 2 Total Weekly Output	Oper. No. 3 Total Weekly Output	Oper. No. 4 Total Weekly Output	Oper. No. 5 Total Weekly Output	Group Total Weekly Output
No. 1 Base Period in Regular Gang	1	45.67			74,835	72,872	78,584	
	2				78,951	71,975	79,056	
	3				81,794	72,285	78,715	
	4		74,811		82,685	72,881	80,267	
	5		72,356	67,788	78,858	71,450	81,956	
	TOTAL		147,167	67,788	398,123	361,463	398,578	
	Average		73,584	67,788	79,625	72,293	79,716	74,601
No. 2 Special Gang Rate	1	45.67	80,047	78,237	99,563	80,517	86,075	84,888
	2		78,958	76,472	96,431	84,066	85,163	84,218
	3		79,626	80,150	98,567	83,012	87,472	85,764
	4		78,572	76,291	95,906	84,423	86,944	84,427
	5		75,289	78,078	89,069	83,502	83,886	81,966
	6		78,334	77,499	90,297	83,357	87,753	83,449
	7		79,196	78,047	95,427	81,761	84,866	83,860
	8		77,324	76,305	90,359	83,505	86,270	82,752
	9		79,010	79,381	88,236	79,648	Abs.	81,556
No. 3 Return to Regular Gang	1	45.67	72,841	78,995	48,274	82,872	Abs.	70,747
	2		75,369	81,756	48,754	84,185	Abs.	72,517
	3		74,781	77,706	52,424	82,431	Abs.	71,933
	4		69,515	71,513	51,331	81,032	Transferred	68,349
	5		70,625	68,951	51,707	75,916	"	66,826
	6		68,845	69,786	Transferred	80,381	"	71,947
	7		Transferred	Transferred	"	81,411	"	

B. THE MICA GROUP

As a further check upon the results of the test room studies, a group of operators was sought whose working conditions might be changed without changing the basis of pay. It was decided to set up a test room with a group of five mica splitters, making the test room conditions like those which have previously been maintained for the relay assembly test.

The work of a mica splitter is to separate thick sheets of mica into thin sheets of standard thickness (a few thousandths of an inch) with a pointed instrument. Each thin sheet is than tested in automatic calipers to determine whether it is within the limits of thickness allowed. Rough edges of mica are trimmed with shears when necessary. This work requires precise movements and close attention. The foreman of a mica splitting group stated that the expertness and output of an operator increases appreciably over the first two or three years of work on this job.

1. Precedure

The output of five experienced operators was determined over a period of eight weeks beginning August 27, 1928. During this time the girls were working in the regular department and did not know that output records were being taken or that any special attention was being paid to their production. All workers in this group are paid on a straight piece work basis.

The output of these operators during the eight weeks was taken as a base rate.

On October 22, 1928, the five operators were moved to a small test room, well lighted by large windows at the left of the operators, and partly partitioned off from one of regular departments. The plan of the test study was to try the effect of rest pauses. This was explained to these operators. They were willing to enter upon the study and were interested in it. The quality of mica and the ease with which it can be split inevitably fluctuates somewhat, but general working equipment so far as desks, chairs, instruments, and lighting are concerned were of the same type in the test room as they were in the regular department.

For five weeks (in the test room) the operators were kept upon a full working day exactly like that upon which they had been working in the regular department. Two ten minute rest pauses were then provided, one at 9:30 A.M. and the other at 2:30 P.M. These working conditions have been continued to the present time. The reason for making this a long period lay in the fact that the output of the relay assembly test room operators has shown a continual upward trend which was independent

of the number and length of rest pauses. The longer continuation of this feature should help to determine the maximum effect of each change in working conditions.

2. The Individual Operators

For each operator certain facts were determined and certain information was collected which may have a bearing on her output. General information of this type is included in the following statements:

Operator No. 1:

The girl is a severe mental, or problem case. She has had several "nervous breakdowns" and does not seem to have many friends. She is a widow, has a son and daughter, both of whom will graduate from grammar school in June, 1929. She is dissatisfied with her present home, which she rents, and wants to secure a place with more ground so that she may have a "garden and flowers." She is extremely concerned regarding the outlook for the future of her children and attends lectures on Child Welfare and related subjects. She does a great deal of reading; is over cautious about her diet. She lost her home - or that part which was paid in - through some questionable real estate deal. Her mental condition, as expressed by her remarks, has improved considerably since coming on the test and she is "happier" and is gaining weight. She is forty years of age. She has been with the Company approximately nine years. She has been splitting mica for five years.

Operator No. 2:

Has a pleasant attitude toward life. She is a widow and has one daughter who is also employed by the Company. She maintains the home. She has worked here twelve years, and is forty-one years of age. She has been splitting mica for two and one-half years.

Operator No. 3:

Is single. She has no responsibilities and has savings deductions made from her weekly pay amounting to $15.50. She is employed during lunch and dinner hour as a cashier in the Company Restaurant. She lives in a furnished room. She has been with the Company nine years, and is twenty-eight years of age. She has been splitting mica for four years.

Operator No. 4:

Is a divorcee. She has one child, but is apparently without a serious sense of obligation. She had a son who died. She worked for the Company previous to marriage. She has been working for the Company a total of seventeen years and is thirty-seven years of age. She has been splitting mica for ten years.

Operator No. 5:

Is restrained by severe parental discipline, especially from her mother. Her mother acquires her entire pay, and allows her a meager amount for spending. She is moody and emotional. She has $2 taken out of her pay each week as a savings in the Ready Money Plan. She would like to increase this to $5 a week "if mother wouldn't find out," but is "afraid mother will find out." She is subscribing to five shares of A. T. & T. stock which her father, who is more sympathetic than her mother, assures her will be hers when they are paid up.

The mother wants to return to Austria where this operator was born, and wants to take the father and younger brother, leaving the operator here to work and send the mother her money. The mother removed her from school when in the seventh grade. The operator has a sister in the second year of high school, who the mother says will have to discontinue, as she is "too big to go to school." The operator was laid off during the slack period after working six months. She has a total length of service of one year and six months, and is eighteen years of age. She has been splitting mica for one year and four months.

3. Results to Date

All of these data (including base period and test room periods) have been collected under overtime conditions. On four days a week these girls have been working 9-3/4 hours since August, 1928. They usually worked Saturday afternoon and they have sometimes worked on Sunday.

The output data for this group follows in the form of (1) a basic data table, (2) table No. 1 giving hourly output and percentage of efficiency, and (3) table No. 3 giving weekly output for each operator and for the group as a whole.

Although this test has not progressed very far, certain significant facts may be noted. The output in the test room first fell below that during the base period in the regular department. Factors which may have been responsible for this are the new and unaccustomed conditions of a strange room in which to work and the fact that, due to difficulties in heating, the temperature was lower in this room during part of this period than in the regular shop department. A similar decline in output was experienced with the relay assembly test group when they were moved to the test room.

It will be seen from the tables and from the graphs of total weekly output and percentage of efficiency that the output during the first few weeks of the ten minute rest pause was lower than that for the base period. The efficiency of the operators gradually increased, however, until it more than compensated for the time taken out in rest pauses. There has been a gradual and reasonably continuous increase in efficiency and output. Since the sixth week of this period they both have been above corresponding figures for the base period. The hourly output has increased about 10%. It would be necessary for it to increase only 4% to offset the time lost in rest periods. The total output has been increased about 6%.

A study of the output and efficiency records of individual operators in the following graphs shows a high fluctuation from week to week on the part of operators Nos. 1 and 5 with a definite improvement in consistency for operator No. 1 during the more recent weeks. A study of the data given above for these operators (reflecting their mental and home conditions) suggests a reason for this wide fluctuation.

4. Conclusions

Two facts of interest have appeared in connection with this study to date.

(a) Five experienced mica splitters who have always been paid on a straight individual piece work basis have increased their rate of output about 10% and their total output about 6% under test room conditions with two ten minute rest periods in the working day.

(b) Two operators with unsatisfactory home conditions and unstable emotional status show excessive variation in their output from day to day and from week to week.

BASIC DATA TABLE FOR MICA GROUP*

DAILY OUTPUT IN TERMS OF NUMBER OF PIECES OF MICA SPLIT OFF

Date	Hr.& Min. Worked**	Operators 1	2	3	4	5	Av. for Group
PERIOD NO. 1 - BASE PERIOD IN REGULAR DEPARTMENT							
8-27-28	8:45	1344	1571	1750	Vacation	1615	1570
8-28	8:45	1436	1571	1750	"	1642	1600
8-29	8:45	"1494"	1546	1885	"	1250	1544
8-30	8:45	1571	1571	1750	"	1346	1559
8-31	8:45	1579	1631	1750	"	1346	1576
9- 1	4:15	(1621) 787	(1659)806	(1771)860	"	(1073)521	(1531)744
Total	48:00	8211	8696	9745		7720	8593
9-3-28	8:45	"1650"	"1608"	"1819"	"1671"	"1652"	1680
9-4	8:45	1579	1628	1816	1649	1634	1661
9-5	8:45	1650	1610	1823	1635	1710	1686
9-6	8:45	1598	1586	1780	1590	1650	1641
9-7	8:45	1642	1615	1880	1788	1634	1712
9-8	4:15	(1817) 883	(1603)779	(1807)878	(1693)822	(1637)785	(1711)831
Total	48:00	9002	8826	9996	9155	9075	9211
9-10-28	8:45	1696	1544	1859	1690	1660	1690
9-11	8:45	1705	1552	1847	1705	1660	1694
9-12	8:45	1647	1544	1812	1600	1650	1651
9-13	8:45	1705	1526	1805	1658	1381	1615
9-14	8:45	1509	1425	1824	1673	1660	1618
9-15	4:15	(1528) 742	(1139) 553	(1623) 788	(1740) 845	(1726) 839	(1551) 753
Total	48:00	9004	8144	9935	9171	8850	9021
9-17-28	8:45	1533	Vacation	1817	1635	1660	1661
9-18	8:45	1467	"	1750	1547	1627	1598
9-19	8:45	1474	"	1770	1640	1569	1613
9-20	8:45	1489	"	1805	1682	1660	1659
9-21	8:45	1705	"	1805	1660	1624	1699
9-22	4:15	(1750) 850	"	(1750) 850	(1694) 823	(1739) 844	(1733) 842
Total	48:00	8518		9797	8987	8984	9072

* Refer to explanation at beginning of Basic Data Table for First Relay Assemblers Group, page 6.

** All output figures have been reduced to equivalent figures corresponding to no overtime.

Date	Hr.& Min. Worked	Operators 1	2	3	4	5	Av. for Group
9-24-28	8:45	1705	1526	1251	1703	898	1417
9-25	8:45	1581	1526	1805	1336	1264	1502
9-26	8:45	1530	1540	1812	1650	1500	1606
9-27	8:45	1571	1690	1838	1677	1257	1607
9-28	8:45	1346	1400	1827	1678	1362	1523
9-29	4:15	(1734) 842	(1479) 718	(1819) 884	(1763) 856	(1249) 606	(1609) 781
Total	48:00	8575	8400	9417	8900	6887	8436
10-1-28	8:45	1513	1518	1860	1677	1670	1648
10-2	8:45	1678	1540	1828	1673	1670	1678
10-3	8:45	1920	1500	1852	1659	1626	1711
10-4	8:45	1891	1531	1825	1675	1670	1718
10-5	8:45	1702	1526	1863	1660	1660	1682
10-6	4:15	(1575) 765	(1554) 755	(1742) 846	(1637) 795	(1129) 548	(1527) 742
Total	48:00	9469	8370	10074	9139	8844	9179
10-8-28	8:45	1897	1526	1805	1526	1264	1603
10-9	8:45	1697	1436	1805	1600	1526	1613
10-10	8:45	1713	1400	1812	1650	1400	1595
10-11	8:45	1701	1566	1870	1747	1439	1665
10-12	8:45	1760	1526	1859	1678	1445	1653
10-13	4:15	(1817) 882	(1355) 658	(1589) 772	(1656) 805	(1250) 607	(1533) 745
Total	48:00	9650	8112	9923	9006	7681	8874
10-15-28	8:45	1660	1499	1802	1556	1543	1612
10-16	8:45	1643	1523	1805	1542	1265	1556
10-17	8:45	1711	1506	1820	1610	900	1509
10-18	8:45	1687	1508	1817	1587	1607	1641
10-19	8:45	1526	1346	1874	1669	1481	1579
10-20	4:15	(1327) 645	(1117) 543	(1880) 913	(1780) 864	(1299) 631	(1481) 719
Total	48:00	8872	7925	10031	8828	7427	8616
Period	*384.00	71301	58473	78918	63186	65468	71002
Av.Hr. Output		185.7	174.0	205.5	188.0	170.5	184.9

*336.00 Hours for Operators No. 2 and 4.

PERIOD NO. 2 - INTRODUCTION TO TEST ROOM							
10-22-28	8:45	1359	1428	1802	1750	1704	1609
10-23	8:45	1086	1400	1800	1732	1600	1524
10-24	8:45	1530	1500	1693	1650	1650	1605
10-25	8:45	1459	1481	1700	1683	1660	1597
10-26	8:45	1517	1481	1680	1693	1667	1567
10-27	4:15	(1543) 749	(1478) 718	(1735) 845	(1742) 846	(1587) 771	(1617) 785
Total	48:00	7500	8008	9518	9354	9052	8687

Date	Hr.& Min. Worked		Operators 1	2	3	4	5	Av. for Group
10-29-28	8:45		1761	1436	1708	1726	1552	1637
10-30	8:45		1739	1526	1716	1711	*1599	1658
10-31	8:45		1573	1516	1704	1767	1511	1614
11-1	8:45		1649	1534	1710	1694	*1386	1595
11-2	8:45		1621	1416	1582	1437	1310	1473
11-3	4:15	(1536)	746	(1307) 635	(1709) 830	(1694) 823	(1355) 658	(1520) 738
Total	48:00		9089	8063	9250	9158	8016	8715
11-5-28	8:45		1642	1477	1802	1687	1327	1587
11-6	8:45		1586	1354	1705	1691	1257	1519
11-7	8:45		1536	1430	1693	1748	1559	1593
11-8	8:45		1604	1444	1638	1750	1463	1580
11-9	8:45		1580	1450	1576	1687	1542	1567
11-10	4:15	(1474)	716	(1446) 702	(1649) 801	(1653) 803	(1253) 609	(1495) 726
Total	48:00		8664	7857	9215	9366	7757	8572
11-12-28	8:45		1560	1491	1564	1692	1184	1498
11-13	8:45		1455	1487	1600	1711	1441	1539
11-14	8:45		1265	1362	1604	1687	1219	1427
11-15	8:45		1389	1487	1521	1546	1489	1486
11-16	8:45		1454	1476	1586	1710	1122	1470
11-17	4:15	(1580)	768	(1423) 691	(1693) 822	(1763) 856	(1389) 674	(1570) 762
Total	48:00		7891	7994	8697	9202	7129	8182
11-19-28	8:45		1732	1346	1650	1732	1394	1571
11-20	8:45		1533	1616	1661	1687	1615	1622
11-21	8:45		1568	1548	1735	1730	1388	1594
11-22	8:45		1571	1526	1700	1687	1347	1566
11-23	8:45		1460	1511	1695	1582	1481	1546
11-24	4:15	(1016)	493	(1341) 651	(1693) 822	(1687) 819	(1072) 521	(1562) 661
Total	48:00		8357	8198	9263	9237	7746	8560
Period	240:00		41501	40120	45943	46317	39700	42716
Av.Hr. Output			172.9	167.2	191.4	193.0	165.4	178.0

* Repair Days. On account of the infrequency of repairs the total daily output for those days has been given a proportionate increase and added directly into the total for the week, instead of carrying both actual and adjusted figures in the table.

PERIOD NO. 3 - TWO 10 MINUTE RESTS

11-26-28	8:25		1593	1385	1713	1710	1319	1544
11-27	8:25		"1618"	1410	1744	1720	1242	1547
11-28	8:25		1676	1462	1758	1649	1296	1568
11-29	8:25		"1618"	"1406"	"1718"	"1699"	"1300"	"1548"
11-30	8:25		1635	1403	1694	1682	1295	1542
12-1	4:05	(1546)	750	(1364) 662	(1677) 813	(1755) 842	(1361) 660	(1537) 745
Total	46:10		8890	7728	9440	9302	7112	8494

Date	Hr. & Min. Worked	Operators 1	2	3	4	5	Av. for Group
12-3-28	8:25	1700	1374	1740	1692	1631	1627
12-4	8:25	1687	1468	1730	1702	1702	1662
12-5	8:25	1649	1464	1758	1682	1711	1653
12-6	8:25	1642	1255	1702	1683	1537	1564
12-7	8:25	1416	1385	1746	1706	1517	1554
12-8	4:05	(1284) 622	(1502) 728	(1576) 764	(1665) 807	(1683) 816	(1542) 747
Total	46:10	8716	7692	9440	9272	8914	8807
12-10-28	8:25	1849	1427	1752	1711	1596	1667
12-11	8:25	1837	1564	1788	1752	1581	1704
12-12	8:25	1689	1559	1731	1687	1427	1619
12-13	8:25	1611	1612	1833	1782	1599	1687
12-14	8:25	1617	1533	1754	1666	1510	1616
12-15	4:05	(1361) 660	(1475) 715	(1789) 868	(1722) 835	(1220) 592	(1513) 734
Total	46:10	9263	8410	9726	9433	8305	9027
12-17-28	8:25	1473	1345	1804	"1727"	1472	1564
12-18	8:25	1642	1455	1772	1773	1546	1638
12-19	8:25	1526	1420	1758	1688	1438	1566
12-20	8:25	1608	1447	1715	1691	1071	1506
12-21	8:25	1528	1507	1746	1691	1397	1574
12-22	4:05	(1562) 758	(1423) 690	(1688) 819	(1804) 875	(1328) 644	(1561) 757
Total	46:10	8535	7864	9614	9445	7568	8605
12-24-28	8:25	1632	1379	1839	1846	1155	1570
12-25	8:25	"1724"	"1454"	"1845"	"1774"	"1228"	"1605"
12-26	8:25	1715	1420	1905	1750	1100	1578
12-27	8:25	1939	1503	1807	1742	1330	1664
12-28	8:25	1570	1496	1824	1769	1307	1593
12-29	4:05	"(1724) "856"	"(1454) "705"	"(1845) "895"	"(1774) "861"	"(1228) "596"	"(1605) "779"
Total	46:10	9416	7957	10115	9742	6716	8789
12-31-28	8:25	1710	1563	1815	1836	1733	1731
1-1-29	8:25	"1635"	"1469"	"1811"	"1751"	"1569"	"1647"
1-2	8:25	"1635"	1511	1792	1800	1595	1667
1-3	8:25	1668	1437	1810	1707	1534	1631
1-4	8:25	1659	1479	1849	1680	1499	1633
1-5	4:05	(1514) 735	(1354) 657	(1784) 866	(1751) 850	(1508) 732	(1582) 768
Total	46:10	9042	8116	9943	9624	8662	9077
1-7-29	8:25	1574	1440	1815	1698	991	1504
1-8	8:25	1690	1440	1839	1714	1260	1590
1-9	8:25	1698	1510	1815	1743	*1375	1628
1-10	8:25	1704	1456	1790	1714	1239	1581
1-11	8:25	1704	1485	1815	1687	1305	1599
1-12	4:05	(1395) 677	(1475) 716	(1629) 790	(1791) 869	(1121) 544	(1482) 719
Total	46:10	9055	8047	9864	9425	6714	8621

Date	Hr. & Min. Worked		Operators 1		2		3		4		5		Av. for Group
1-14-29	8:25		1943		1541		1792		1796		1295		1673
1-15	8:25		1709		1535		1782		1683		1454		1632
1-16	8:25		1865		1651		1917		1709		1317		1692
1-17	8:25		1758		1501		1872		1778		1430		1668
1-18	8:25		1698		1475		1815		1698		1474		1652
1-19	4:05	(1602)	777	(1475)	715	(1518)	737	(1712)	831	(1232)	598	(1508)	732
Total	46:10		9750		8418		9915		9495		7568		9029
1-21-29	8:25		1708		1512		1828		1723		1307		1616
1-22	8:25		1600		1485		1798		1736		1406		1605
1-23	8:25		1538		1504		1790		1712		1512		1611
1-24	8:25		1579		1477		1835		1699		1347		1588
1-25	8:25		1758		1449		1826		1794		1410		1647
1-26	4:05	(1325)	643	(1486)	"721"	(1741)	844	(1840)	893	(1288)	625	(1536)	745
Total	46:10		8826		8148		9921		9557		7607		8812
1-28-29	8:25		1616		"1523"		1962		1716		1437		1651
1-29	8:25		1787		1643		1860		1847		1715		1770
1-30	8:25		1745		1640		1820		1812		1686		1741
1-31	8:25		1691		1490		1745		1766		1773		1693
2-1	8:25		1599		1430		1710		1698		1552		1598
2-2	4:05	(1472)	714	(1397)	678	(1775)	861	(1821)	884	(1446)	702	(1582)	768
Total	46:10		9152		8404		9958		9723		8865		9221
2-4-29	8:25		1653		1444		1837		1710		1315		1592
2-5	8:25		1601		1501		1790		1728		1652		1654
2-6	8:25		1502		1578		1780		1688		1420		1594
2-7	8:25		1649		1503		1764		1714		1608		1648
2-8	8:25		1715		1574		1758		1777		1760		1717
2-9	4:05	(1661)	806	(1527)	741	(1658)	804	(1847)	896	(1590)	771	(1657)	803
Total	46:10		8926		8341		9733		9513		8526		9008
2-11-29	8:25		1888		1639		1774		1842		1604		1749
2-12	8:25		1876		1591		1792		1831		1774		1773
2-13	8:25		1807		1547		1722		1834		1200		1622
2-14	8:25		1720		1458		1847		1787		1882		1739
2-15	8:25		1921		1470		1815		1742		1709		1731
2-16	4:05	(1605)	779	(1385)	672	(1681)	815	(1847)	896	(1374)	667	(1578)	766
Total	46:10		9991		8377		9765		9932		8836		9380
2-18-29	8:25		1662		1365		1692		1751		1528		1600
2-19	8:25		1698		1501		1794		1731		1537		1652
2-20	8:25		1630		1466		1823		1730		1400		1610
2-21	8:25		1581		1492		1908		1707		1472		1632
2-22	8:25		1723		1548		1803		1735		* 931		1548
2-23	4:05	(2072)	1005	(1611)	782	(1836)	891	(1815)	880	(1583)	768	(1783)	865
Total	46:10		9299		8154		9911		9534		7636		8907

* Repair Days

Date	Hr. & Min. Worked		Operators 1		2		3		4		5		Av. for Group
2-25-29	8:25		1969		1723		1940		1885		1459		1795
2-26	8:25		1899		1677		1928		1767		1560		1766
2-27	8:25		1887		1546		1954		1806		1290		1697
2-28	8:25		1762		1577		1826		1804		1551		1704
3-1	8:25		1798		1553		1799		1796		1467		1683
3-2	4:05	(1800)	873	(1449)	703	(1745)	846	(1840)	895	(1549)	751	(1677)	813
Total	46:10		10188		8779		10293		9951		8078		9458
3-4-29	8:25		1707		1359		1761		1731		*1368		1585
3-5	8:25		1644		1413		1772		1731		*1082		1528
3-6	8:25		1800		1500		1767		1760		1600		1685
3-7	8:25		1742		1546		1824		1725		1448		1657
3-8	8:25		1729		1367		1702		1625		1397		1564
3-9	4:05	(1486)	720	(1341)	650	(1517)	736	(1650)	800	(1156)	560	(1430)	693
Total	46:10		9342		7835		9562		9372		7455		8712
3-11-29	8:25		1735		1596		1837		1742		1546		1691
3-12	8:25		1653		1500		1838		1720		1608		1684
3-13	8:25		1600		1500		1815		1725		1200		1568
3-14	8:25		1698		1519		1815		1720		1300		1610
3-15	8:25		1767		1537		1779		1769		1662		1703
3-16	4:05	(1739)	844	(1361)	660	(1836)	891	(1853)	899	(1364)	662	(1631)	791
Total	46:10		9297		8312		10075		9575		7978		9047
3-18-29	8:25		1725		1564		1826		1742		1072		1586
3-19	8:25		1730		1564		1820		1744		1544		1680
3-20	8:25		1648		1530		1795		1750		1407		1626
3-21	8:25		1804		1485		1834		1769		1032		1585
3-22	8:25		1742		1538		1833		1742		1608		1693
3-23	4:05	(1873)	908	(1706)	827	(1798)	872	(1857)	900	(1877)	910	(1822)	883
Total	46:10		9557		8508		9980		9647		7573		9053
3-25-29	8:25		1725		1524		1867		1748		1623		1697
3-26	8:25		1738		1528		1815		1769		1685		1707
3-27	8:25		1600		1500		1850		1750		1450		1630
3-28	8:25		1722		1640		1835		1775		1537		1702
3-29	8:25		"1699"		1698		1772		1730		1198		1619
3-30	4:05	"(1699)	""824"	(1795)	870	(1402)	680	(1571)	761	(1149)	557	(1523)	738
Total	46:10		9308		8760		9817		9533		8050		9093
4-1-29	8:25		"1764"		1637		1800		1725		1385		1662
4-2	8:25		1715		1626		1789		1884		1438		1690
4-3	8:25		1745		1600		1815		1725		1600		1697
4-4	8:25		1769		1619		1800		1750		1546		1697
4-5	8:25		1769		1635		1800		1751		1544		1700
4-6	4:05	(1834)	889	(1588)	770	(1815)	880	(1815)	880	(1341)	650	(1679)	814
Total	46:10		9651		8887		9884		9715		8165		9260

* Repair Days

Date	Hr. & Min. Worked	Operators 1	2	3	4	5	Av. for Group
4-8-29	8:25	1742	1608	1800	1766	1430	1669
4-9	8:25	1765	1608	1776	1742	1556	1689
4-10	8:25	1720	1616	1833	1750	1400	1664
4-11	8:25	1742	1625	1830	1759	1579	1707
4-12	8:25	1767	1624	1803	1748	1619	1712
4-13	4:05	(1912) 927	(1622) 786	(1819) 882	(1815) 880	(965) 468	789
Total	46:10	9665	8867	9924	9645	8052	9230
4-15-29	8:25	1778	1653	1800	1742	1608	1716
4-16	8:25	1948	1662	1803	1742	1627	1756
4-17	8:25	1780	1716	1826	1757	1520	1720
4-18	8:25	1778	1653	1800	1698	1653	1717
4-19	8:25	2003	1668	1807	1742	1698	1784
4-20	4:05	(1901) 921	(1563) 758	(1753) 850	(1815) 880	(1645) 797	(1735) 841
Total	46:10	10208	9110	9886	9561	8903	9534
4-22-29	8:25	1900	1500	1781	1750	1000	1586
4-23	8:25	1668	1668	1712	1826	1650	1705
4-24	8:25	1860	1400	1815	1750	1610	1687
4-25	8:25	1753	1446	1809	1750	1620	1676
4-26	8:25	1758	1447	1812	1769	1627	1683
4-27	4:05	(1895) 918	(1573) 665	(1650) 800	(1679) 814	(1638) 794	(1647) 798
Total	46:10	9857	8126	9729	9659	8301	9135
4-29-29	8:25	1773	1448	1762	"1757"	1603	1669
4-30	8:25	1785	1549	1836	"1757"	1622	1710
5-1	8:25	1650	1500	1815	1775	1500	1648
5-2	8:25	1775	1420	1850	1650	1616	1662
5-3	8:25	1789	1521	1800	1786	1010	1581
5-4	4:05	(1898) 920	(1422) 689	(1813) 879	(1827) 886	(1321) 640	(1656) 803
Total	46:10	9692	9127	9942	9611	7991	9073
5-6-29	8:25	1778	1444	1807	1759	*1752	1708
5-7	8:25	1775	1538	1762	1757	1534	1673
5-8	8:25	*1702	1527	1832	1888	1589	1708
5-9	8:25	*1513	1546	1811	1771	1534	1635
5-10	8:25	1558	1551	1850	1784	1548	1658
5-11	4:05	(1758) 852	(1497) 725	(1847) 895	(1868) 905	(1204) 583	(1635) 792
Total	46:10	9178	8331	9957	9864	8540	9174

* Repair Days

TABLE NO. 1
MICA GROUP
Average Hourly Output and Per Cent of Efficiency by Weeks and by Periods

Period	Hrs. of Work Per Wk.	No. of Wk. in Period	Opr. No. 1 Aver. Hourly Output	Opr. No. 1 % of Eff.	Opr. No. 2 Aver. Hourly Output	Opr. No. 2 % of Eff.	Opr. No. 3 Aver. Hourly Output	Opr. No. 3 % of Eff.	Opr. No. 4 Aver. Hourly Output	Opr. No. 4 % of Eff.	Opr. No. 5 Aver. Hourly Output	Opr. No. 5 % of Eff.	Group Aver. Hourly Output	Group % of Eff.
No. 1 Base Period in Regular Department	48	1	171.1	92.1	181.2	104.1	203.0	98.8	Vac.	Vac.	160.8	94.3	179.0	96.8
		2	187.5	101.0	183.9	105.7	208.2	101.3	190.7	101.4	189.1	110.9	191.9	103.8
		3	187.6	101.0	169.7	97.5	207.0	100.7	191.1	101.6	184.4	108.2	188.0	101.7
		4	177.5	95.6	Vac.	Vac.	204.1	99.3	187.2	99.6	187.2	109.8	189.0	102.2
		5	178.6	96.2	175.0	100.6	196.2	95.5	185.4	98.6	143.5	84.2	175.7	95.0
		6	197.3	106.2	174.4	100.2	209.9	102.1	190.4	101.3	184.3	108.1	191.3	103.5
		7	201.0	106.2	169.0	97.1	206.7	100.6	187.6	99.8	160.0	93.8	184.9	100.0
		8	184.8	99.5	165.1	94.9	209.0	101.7	183.9	97.8	154.7	90.7	179.5	97.1
		AVER.	185.7	100.0	174.0	100.0	205.5	100.0	188.0	100.0	170.5	100.0	184.9	100.0
No. 2 Introduction to Test Room	48	1	156.3	84.2	166.8	95.9	198.3	96.5	194.9	103.7	188.6	188.6	181.0	97.9
		2	189.4	102.0	168.0	96.6	192.7	93.8	190.8	101.5	167.0	97.9	181.6	98.2
		3	180.5	97.2	163.7	94.1	192.0	93.4	195.1	103.8	161.6	94.8	178.6	96.6
		4	164.4	88.5	166.5	95.7	181.2	88.2	191.7	102.0	148.5	87.1	170.5	92.2
		5	174.1	93.8	179.8	98.2	193.0	93.9	192.4	102.3	161.4	94.7	178.3	96.4
		AVER.	172.9	93.1	167.2	96.1	191.4	93.1	193.0	102.7	165.4	97.0	178.0	96.3
No. 3 Two 10-Minute Rests	46.17	1	192.6	103.7	167.4	96.2	204.5	99.5	201.5	107.2	154.1	90.4	184.0	99.5
		2	188.8	101.7	166.6	95.7	204.5	99.5	200.8	106.8	193.1	113.3	190.8	103.2
		3	200.6	108.0	182.2	104.7	210.7	102.5	204.3	108.7	179.9	105.5	195.5	105.7
		4	184.9	99.6	170.3	97.9	208.2	101.3	204.6	108.8	163.9	96.1	186.4	100.8
		5	203.9	109.8	172.3	99.0	219.1	106.6	211.0	112.2	145.5	85.3	190.4	103.0
		6	195.8	105.4	175.8	101.0	215.4	104.8	208.4	110.9	187.6	110.0	196.6	106.3
		7	196.1	105.6	174.3	100.2	213.6	103.9	204.1	108.6	145.4	85.3	186.7	101.0

Period	Hrs. of Work Per Wk.	No. of Wk. in Period	Opr. No. 1 Aver. Hourly Output	Opr. No. 1 % of Eff.	Opr. No. 2 Aver. Hourly Output	Opr. No. 2 % of Eff.	Opr. No. 3 Aver. Hourly Output	Opr. No. 3 % of Eff.	Opr. No. 4 Aver. Hourly Output	Opr. No. 4 % of Eff.	Opr. No. 5 Aver. Hourly Output	Opr. No. 5 % of Eff.	Group Aver. Hourly Output	Group % of Eff.
No. 3(Cont'd)														
Two 10-Minute Rests	46.17	8	211.2	113.7	182.3	104.8	214.8	104.5	205.7	109.4	163.9	96.1	195.6	105.8
	9	191.2	103.0	176.5	101.4	214.9	105.6	207.0	110.1	164.8	96.7	190.9	103.2	
	10	198.2	106.7	182.0	104.6	215.7	105.0	210.6	112.0	192.0	112.6	199.7	108.0	
	11	193.3	104.1	180.7	103.9	210.8	102.6	206.0	109.6	184.7	108.7	195.1	105.5	
	12	216.4	116.5	181.4	104.3	211.5	102.9	215.9	114.4	191.4	112.3	203.2	109.9	
	13	201.4	108.5	176.6	101.5	214.7	104.5	206.5	109.8	165.4	97.0	192.9	104.3	
	14	220.7	118.8	190.1	109.3	222.9	108.5	215.5	114.6	175.0	102.6	204.9	110.8	
	15	202.3	108.9	169.7	97.5	207.1	100.8	203.0	108.0	161.5	94.7	188.7	102.1	
	16	201.4	108.5	180.0	103.4	218.2	106.2	207.4	110.3	172.8	101.3	195.9	105.9	
	17	207.0	111.5	184.3	105.9	216.2	105.2	208.9	111.1	164.0	96.2	196.1	106.1	
	18	201.6	108.5	189.7	109.0	212.6	103.5	206.5	109.8	174.4	102.3	196.9	106.5	
	19	209.0	112.5	192.5	110.6	214.1	104.2	210.4	111.9	176.8	103.7	200.6	108.5	
	20	209.3	112.7	192.1	110.4	214.9	104.6	208.9	111.1	174.4	102.3	199.9	108.1	
	21	221.1	119.1	197.3	113.4	214.1	104.2	207.1	110.2	192.8	113.1	206.5	111.7	
	22	213.5	115.0	176.0	101.1	210.7	102.5	209.2	111.3	179.8	105.5	197.9	107.0	
	23	209.9	113.0	176.0	101.1	215.3	104.8	208.2	110.7	173.1	101.5	196.5	106.3	
	24	198.8	107.1	180.4	103.7	215.7	105.0	213.6	113.6	185.0	108.5	198.7	107.5	

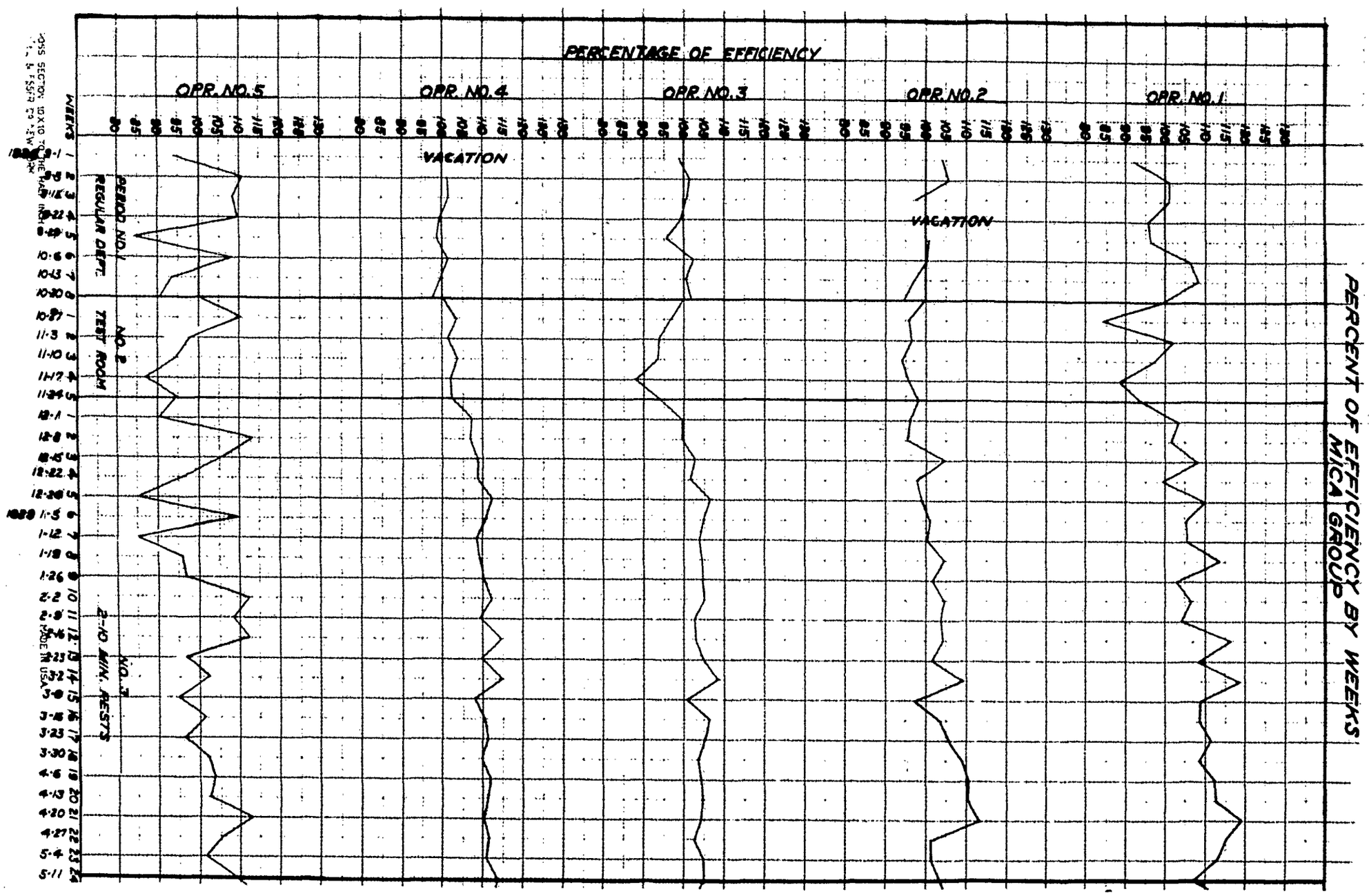
TABLE NO. 3
MICA GROUP

Total Weekly Outputs and Average Weekly Output By Periods Of Test

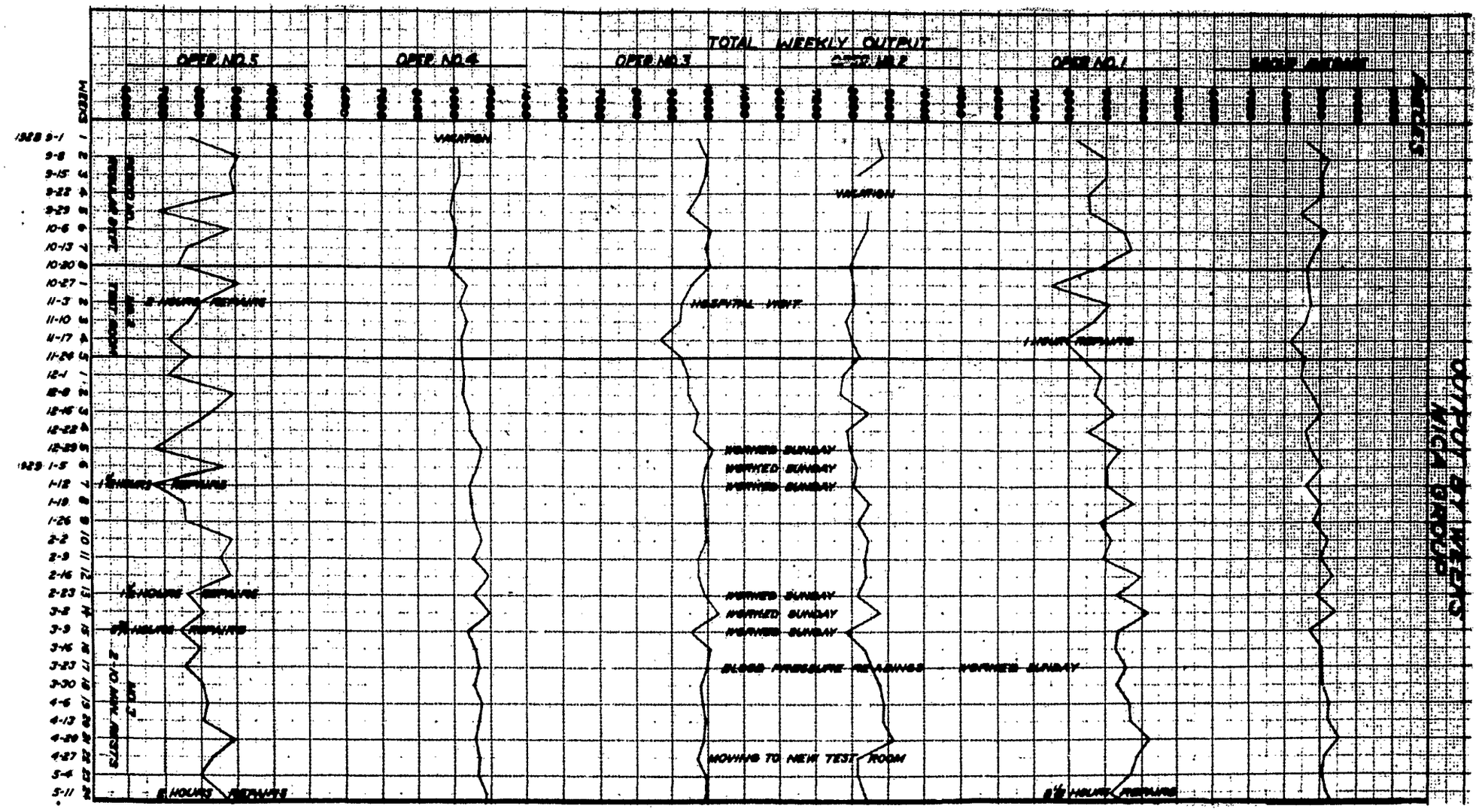
Period	Hrs. of Work* per Wk.	No. of Wk. in period	Oper. No. 1 Total Weekly Output	Oper. No. 2 Total Weekly Output	Oper. No. 3 Total Weekly Output	Oper. No. 4 Total Weekly Output	Oper. No. 5 Total Weekly Output	Group Total Weekly Output
No. 1	48.00	1	8211	8696	9745	VAC.	7720	8593
Base Period		2	9002	8826	9996	9155	9075	9211
in Regular		3	9004	8144	9935	9171	8850	9021
Dept.		4	8518	VAC.	9797	8987	8984	9072
		5	8575	8400	9417	8900	6887	8436
		6	9469	8370	10074	9139	8844	9179
		7	9650	8112	9923	9006	7681	8874
		8	8872	7925	10031	8828	7427	8616
		TOTAL	71301	58473	78918	63186	65468	71002
		Average	8912.6	8353.3	9864.8	9026.6	8183.5	8875.3
No. 2	48.00	1	7500	8008	9518	9354	9052	8687
Introduction		2	9089	8063	9250	9158	8016	8715
to Test Room		3	8664	7857	9215	9366	7757	8572
		4	7891	7994	8697	9202	7129	8182
		5	8357	8198	9263	9237	7746	8560
		TOTAL	41501	40120	45943	46317	39700	42716
		Average	8300.2	8024.0	9188.6	9263.4	7940.0	8543.2
No. 3	46.17	1	8890	7728	9440	9302	7112	8494
Two 10 Min.		2	8716	7692	9440	9272	8914	8807
Rests		3	9263	8410	9726	9433	8305	9027
		4	8535	7864	9614	9445	7568	8605
		5	9416	7957	10115	9742	6716	8789
*See next page		6	9042	8116	9943	9624	8662	9077

Period	Hrs. of Work per Wk.	No. of Wk. in period	Oper. No. 1 Total Weekly Output	Oper. No. 2 Total Weekly Output	Oper. No. 3 Total Weekly Output	Oper. No. 4 Total Weekly Output	Oper. No. 5 Total Weekly Output	Group Total Weekly Output
No. 3 Cont'd Two 10 Min. Rests	46.17	7	9055	8047	9864	9425	6714	8621
		8	9750	8418	9915	9495	7568	9029
		9	8826	8148	9921	9557	7607	8812
		10	9152	8404	9958	9723	8865	9221
		11	8926	8341	9753	9513	8526	9008
		12	9991	8377	9765	9932	8836	9380
		13	9299	8154	9911	9534	7636	8907
		14	10188	8779	10293	9951	8078	9458
		15	9342	7835	9562	9372	7455	8712
		16	9297	8312	10075	9575	7978	9047
		17	9557	8508	9980	9647	7573	9053
		18	9308	8760	9817	9533	8050	9093
		19	9651	8887	9884	9715	8165	9260
		20	9663	8867	9924	9645	8052	9230
		21	10208	9110	9886	9561	8903	9534
		22	9857	8126	9729	9659	8301	9135
		23	9692	8127	9942	9611	7991	9073
		24	9178	8331	9957	9864	8540	9174

* All output figures have been reduced to equivalent figures corresponding to no overtime.



UNIVERSITY OF WISCONSIN - MILWAUKEE



11/96

UNIVERSITY OF WISCONSIN - MILWAUKEE

C. TYPEWRITING GROUP

There are occasionally opportunities to make observations upon working conditions without setting up test room experiments. It is worthwhile to take advantage of such opportunities to supplement former studies without appreciable cost and to gain further information of industrial significance. An opportunity for such observation was found in a typist group. These girls are paid on a weekly salary basis, but their increases in salary are based primarily upon output which is determined by an automatic recording device on the machine indicating the number of keys struck.*

Information has been gathered concerning the home conditions and temperament of these girls. Their individual comments concerning rest pauses were secured. These comments were almost universally favorable. Their outputs by thirty minute periods were determined for two successive weeks. The fluctuation of output during the different hours of the day and during the different days of the week is shown on the following graph. Information has also been gathered as to the nature of the fatigue experienced by these workers.

The advantages of studying this group lie in the fact that the work involves greater mental and less physical effort. Greater concentration is demanded and a better reflection of central nervous system fatigue may be secured. At present the data collected is being used to determine the factors which affect working conditions, output, and fatigue. On the basis of this analysis an attempt will be made to improve working conditions in such directions as seem indicated, particularly by determining the best kinds of rest pauses for this type of work. The results of this observational study will be presented in a later report. Detailed data collected thus far are not presented here because it is too early to draw even tentative conclusions.

D. EFFECT OF OVERTIME ON EFFICIENCY

The need for the plant to increase the amount of overtime during the last few months in order to keep up with the production schedule has raised the question of the effect of longer hours of work upon efficiency. No conclusions are possible from the limited amount of data secured to date, but in two manual operations separately studied, mica splitting and armature straightening, there is no indication of a decrease in the hourly output with the increase in length of the working day from 8-3/4 hours to 9-3/4 hours (changing the length of the week of 48 hours to 55 hours). Further studies are needed. As a matter of interest, however, the limited data already gathered is summarized on the following pages.

*This machine registers "points." One point represents 240 taps on the keyboard.

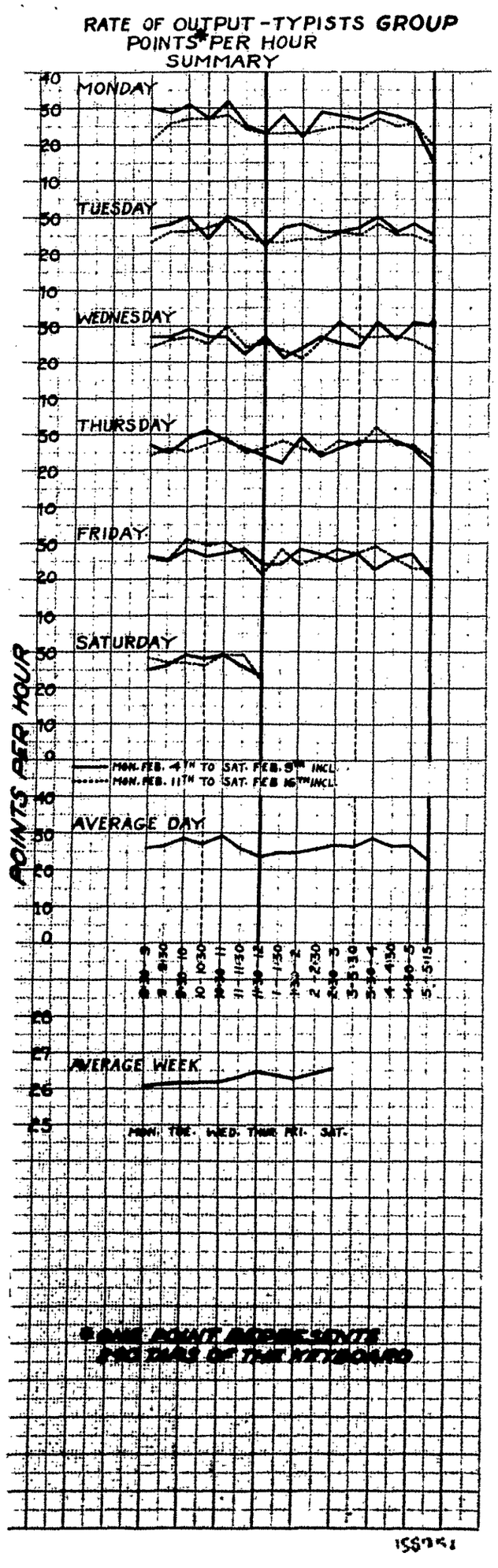

RATE OF OUTPUT - TYPISTS GROUP
POINTS* PER HOUR
SUMMARY
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
MON. FEB. 4TH TO SAT. FEB. 9TH INCL.
MON. FEB. 11TH TO SAT. FEB 16TH INCL.
AVERAGE DAY
AVERAGE WEEK
MON. TUE. WED. THUR. FRI. SAT.
POINTS PER HOUR
* ONE POINT APPROXIMATELY
TWO TIMES OF THE KEYBOARD

TABLE
SUMMARY OF AVERAGE HOURLY OUTPUT OF TEN MICA SPLITTERS
ON STANDARD LENGTH DAYS DURING AUGUST, 1928,
AND ON OVERTIME DAYS DURING JANUARY, 1929.

Clock No.	Age	Length of Service on Mica Years	Months	Av.Hr. Output No Overtime Days		Av.Hr. Output Overtime Days		% of Efficiency Overtime versus No Overtime Days
212	22	1	4	(13)'	184.2	(13)'	196.4	106.6
238	41	1	10	(12)	173.4	(14)	185.9	107.2
267	24	1	6	(12)	189.4	(9)	192.8	101.8
*270	37		7	(13)	137.3	(12)	188.1	137.0
293	42	2		(12)	166.1	(14)	168.6	101.5
296	21	1	4	(12)	194.6	(12)	201.1	103.3
340	21	1	8	(11)	177.5	(12)	191.4	107.8
413	44	16		(12)	181.6	(11)	194.8	107.3
453	29	2	5	(9)	179.3	(11)	195.7	109.1
**473	51	6		(13)	165.7	(12)	160.2	96.7

' Figures in ( ) indicate the number of days used in computing the average.

* Clock No. 270 was the only new operator. She began in July, 1928, which, no doubt, explains the large increase in average hourly output.

** Clock No. 473, the only operator with a lower average hourly output on overtime days is 51 years old. The operator's age and the longer working day may explain the lower average hourly output.

The approximate length of service on mica is of February, 1929. This information was obtained from the gang boss, who, in turn, questioned each operator.

1. Factors Which May Have Influenced Efficiency

Following are some of the reasons which may have influenced the performance of the ten mica splitters, causing the average efficiency to be higher in an overtime period than during a non-overtime period:

1. Average room temperature during August was 77.8 F as compared to 69.9 F for January. The relative humidity for these months respectively was 52.6 and 27.8. Upon questioning the test operators it was learned that on a day when the relative humidity is high, the mica dust gets on the body and causes a disagreeable and annoying itching.

2. The report on 5500 gang piece work operators for three years showed that January earnings were higher than August by about 2%. (See Appendix B.)

3. The possibility of increasing their earnings without the fear of being criticised by other operators may have been a factor. There is greater pressure for production under overtime conditions.

4. These operators may have been on a general upward trend in production. The foreman in a mica splitting group says there is commonly an improvement in output during the first three years.

2. Summary

It appears as though the increase during the overtime period was due mainly to seasonal variation, also that the increased demand for parts, caused a general speeding up. It seems clear, however, that overtime did not cause an appreciable reduction in hourly output in this instance. The same tentative conclusions and general comments apply to the following data gathered on the armature straightening operation.

TABLE
COMPARISON OF PERFORMANCE STUDY
OVERTIME (JANUARY, 1929) VS. NO OVERTIME (AUGUST, 1928)
ARMATURE STRAIGHTENING OPERATION

Clock No.	Age	Approximate Length of Service on Armatures Years	Months	Av.Hr. Output No Overtime Days August 1928		Av.Hr.Output Overtime Days January 1929		% of Efficiency Overtime Versus No Overtime Days
343	18		11	(14)*	269.2	(11)*	309.5	115.0
415	44	5		(10)	342.2	(12)	375.5	109.7
421	27	5		(10)	324.1	(12)	365.3	112.7
424	32	5		(14)	334.8	(12)	331.5	99.0
427	25	5		(9)	331.9	(14)	357.1	107.6
443	32	5		(11)	351.0	(14)	344.3	98.1

Clock No. 343 was the only new operator. She began in April, 1928, which, no doubt, explains the large increase in average hourly output.

The approximate length of service on armature straightening is of March 1929. This information was obtained from the gang boss and the personnel records.

*Figures in ( ) indicate the number of days used in computing the average.

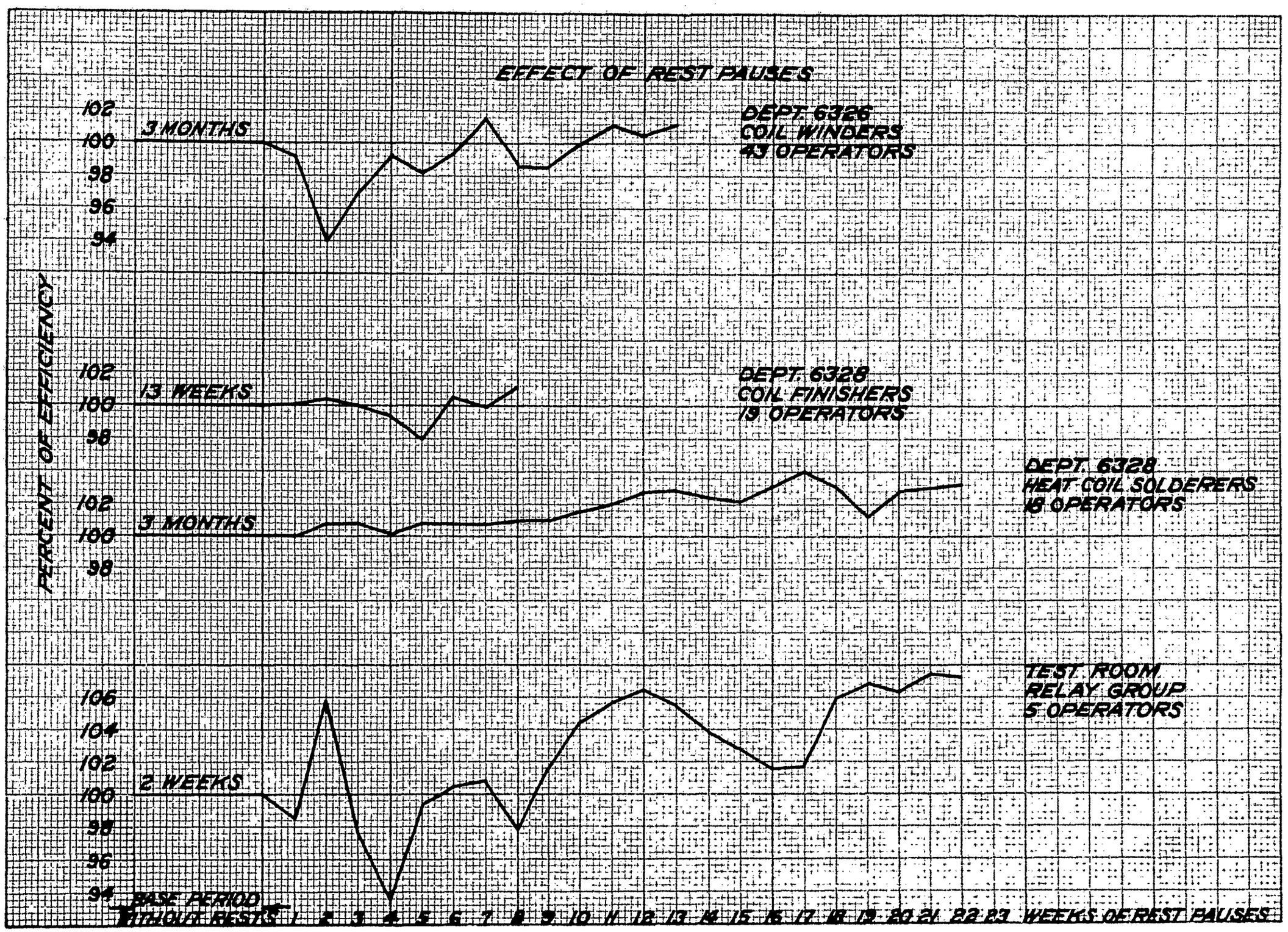
Comment: These data have the same general significance as those for mica splitters, presented on the previous page.

E. EFFECT OF REST PAUSES FOR REGULAR SHOP GROUPS

The results of rest pauses in the test group studies indicated the desirability of establishing rest pauses for several regular shop groups. Starting February, 1928, the entire Relay Assembly Department was placed on a rest pause schedule and other shop departments have since been added until at the present time there are approximately 3000 employees having a rest pause in the morning and afternoon, totalling twenty-five minutes daily.

The production records of several representative groups of these employees were studied over a period of time, both before and after the inauguration of rest pauses, in an effort to determine the effect of rests on production. While only eighty employees' records were studied, the trend of the curves showing their production efficiency parallels similar curves for the test groups.

The following chart contains a graph for each of the shop groups studied.


EFFECT OF REST PAUSES
PERCENT OF EFFICIENCY
102
100
98
96
94
3 MONTHS
DEPT. 6326
COIL WINDERS
43 OPERATORS
13 WEEKS
DEPT. 6328
COIL FINISHERS
19 OPERATORS
3 MONTHS
DEPT. 6328
HEAT COIL SOLDERERS
18 OPERATORS
106
104
2 WEEKS
TEST ROOM
RELAY GROUP
5 OPERATORS
BASE PERIOD WITHOUT RESTS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 WEEKS OF REST PAUSES

124a

SECTION V

OUTCOMES, OBSERVATIONS, AND CONCLUSIONS

A. OUTCOMES

Two outcomes of these studies have been directly applied in regular departments.

1. Because of the findings indicating that rest pauses do not reduce total output but rather tend to increase it, rest pauses have been established in operating departments having similar operations to those studied. At the present time these rest pauses have been extended to about 3000 employees. (Reported in Section IV.)

2. Of still greater importance is the interviewing program.

   The findings concerning the sensitiveness of operators, the vital importance to their happiness of even minor items in the way they are handled and the apparent improvement in work because of a better mental attitude suggested the desirability of still further improvement in the quality of supervision at the lower levels of employment. A separate interviewing study was set up in the Inspection Branch through which a clear picture was secured of those problems, worries, likes, and dislikes of employees which are related to supervision and conditions of work. All data were impersonal. Names of individuals did not appear in the interviewing studies. These interviews furnished "case studies" for supervisory training and this instruction program was put on the "case method" basis.

   The interviewing program in the Inspection Branch produced such a favorable reaction that the program is now being extended to the Operating Branch. A new organization entitled the Industrial Research Division has been set up to administer the interviewing program, the continuation of these studies, and the supervisory training program. The interviewing program is a large administrative project which will be reported upon separately.

Apart from the two outcomes reported above data of practical importance are being accumulated in relation to other problems of direct industrial significance. These problems include: (a) the

desirability or undesirability of the five day week, (b) the probable effect of an eight hour day, (c) the effect of overtime upon output and employment, and (d) means and methods for determining the presence of fatigue.

B. OBSERVATIONS AND CONCLUSIONS

The observations and conclusions given here have been suggested by the results of the experiments conducted thus far. They are not to be construed as final, since further experiments may warrant changing.

For the convenience of the reader, new items in this section are separated from those previously reported.

1. New Items

(a) All relay assembly operators in the test room have appreciably increased their rate of production and output. For some operators the increase in output has been from 35% to 50%.

(b) There has been a continual upward trend in output which has been independent of the changes in rest pauses. This upward trend has continued too long to be ascribed to an initial stimulus from the novelty of starting a special study.

(c) The reduction of muscular fatigue has not been the primary factor in increasing output. Cumulative fatigue is not present.

(d) Payment in the small test room gang instead of with the large gang in the regular department was a factor of appreciable importance in increasing output.

(e) The information already gained concerning the cause of increased output needs to be supplemented by a further relative evaluation of such factors as contentment, training, preoccupation, and concentration.

(f) There has been an important increase in contentment among the girls working under test room conditions.

(g) There has been a decrease in absences of about 80% among the girls since entering the test room group. Test room operators have had approximately one-third as many sick absences as the regular department during the last six months.

(h) Test room indications of the importance of the type of supervision to the contentment of the individual operators have been borne out by the success of the interviewing plan in the Inspection Branch with its consequent extention to the Operating Branch.

(i) With rest pauses there has been a decrease in the variation of output and an increase in the rate of output to the point where these improvements more than compensate for the loss of time and increase the total output. The improvement in consistency in output with a rest pause system would suggest that the operator consciously or unconsciously introduces brief rest pauses or change of pace when the working day is continuous. Regular and recognized rest pauses organize this break of work with a better mental attitude on the part of the operators. The operators took personal time out in addition to the rest pauses except in period No. 6 (six five minute rests).

(k) Output is more directly related to the type of working day than to the number of days in the working week. A five day week did not show any significant improvement in the daily output over that of a five and one-half day week with a similar working day (15 minute morning rest and lunch and 10 minute afternoon rest). Its total output was definitely and proportionately lower.

(l) The afternoon output has definitely improved as compared with forenoon output during the later periods having rest and lunch pauses. During the first 24 weeks of period No. 13, three of the four operators working on flat type relays showed a slightly higher hourly output in the afternoon than in the forenoon. (Comparison has not yet been made for operator No. 5 because of the difficulty of converting the numerous round type relays to a standard type with reference to forenoon and afternoon periods. Further comparisons for each operator for all periods are being computed.)

(m) The output upon the return to the full working day without rest and lunch (period No. 12) was 20% above that of the test room period (period No. 3). This output did not fall off during the twelve weeks of the feature.

(n) Period No. 13 returned the fifteen minute morning rest and lunch and the ten minute afternoon rest. It shows the highest output yet obtained. This further supports the conclusion that rest pauses increase the rate of output sufficiently to improve total output.

(o) The output curves by different days of the week show that Monday has the lowest output. It has been shown that this is not due to "practice effect". Saturday is next lowest. The other four days are fairly uniform. This is regarded as significant in reflecting the absence of cumulative fatigue.

(p) The vascular skin reaction test has shown lower afternoon readings, but in its present state of development it is not sufficiently precise to indicate differences in fatigue during the different hours of a working day or the amount of fatigue at the same time on succeeding days. The afternoon readings are significantly lower than the forenoon readings and afternoon readings following the fatiguing of the hand and lower arm muscles are again significantly lower than the afternoon reading without local fatigue.

(q) Test room operators with lower speed show greater consistency of output than operators with greatest speed. By this greater consistency the former, in part, make up for the difference in the "expected output" as determined by manual ability tests.

(r) The amount of sleep has a minor but definite and significant effect upon output. Individual operators vary in their ability to maintain output when hours of sleep are few.

(s) Less frequent changes in the type of relay being worked upon has not been a factor in increasing the output in the test room.

(t) There is not a decrease in output during days of periodic illness.

(u) The girls prefer the five day week to any feature yet tried.

(v) A new test group of mica splitters who have always been on a straight piece work basis has shown an appreciable increase in efficiency and total output in a special test room with two ten minute rest periods daily.

(w) The limited relative data already secured upon the mica splitting and armature straightening operations fail to show a reduction in hourly output under "overtime" conditions. (Further studies are needed.)

(x) Individual studies in the mica splitting group show a relationship between the emotional status or the home conditions of operators and the consistency of their output.

(y) Observations of operators in the relay assembly test room indicate that their health is being maintained or improved and that they are working within their capacity.

2. Items Previously Reported. (Modified by recent findings where necessary.)

(a) The late morning and afternoon slumps which were thought to be due to fatigue are largely due to production time lost on account of personal time taken by the operators just previous to noon and quitting time.

(b) A slump in production which has been observed to occur in the early afternoon when there is no morning rest and lunch is apparently the result of drowsiness brought about by heavy lunches indulged in by the operators. This is particularly true during the warmer months. These heavy lunches are required because of the long interval between breakfast and lunch time of shop employees.

(c) The rest pauses have a distinct effect upon the uniformity of production. The lowest index of uniformity (morning lunch and rest, afternoon rest and 4:30 stop - period No. 8) was less than half the highest index of uniformity (no rest - period No. 12).

(d) The greatest uniformity of production occurred during period No. 8 immediately following the change of operators Nos. 1 and 2. The uniformity of production during the period just preceding this change was poor. The index of uniformity is consistently lower in the forenoon than in the afternoon.

(e) The highest fluctuation in the rate of working encountered to date exclusive of the "no rest" period No. 12 was during the ten minute rests, period No. 5. Fear of lowered earnings due to maximum amount of time off and consequent spurt in production after each rest was, no doubt, a factor in causing the irregularity in the rate of working during this period.

(f) The operators vary widely in uniformity of performance, but remain in the same relative position when compared with each other in this respect.

(g) The highest average hourly output of relays assembled throughout any experiment completed thus far was obtained over the periods of the "morning lunch, afternoon rest and 4:00 o'clock stop". (Note: Period No. 13 - Morning lunch, afternoon rest and 5:00 o'clock stop is now the highest.)

(h) The total daily outputs are not reduced by rest pauses, but are increased. In all features having rest pauses these increases in production were so great as to exclude the possibility of their being chance variations.

(i) The highest total daily output yet obtained was with the full working day broken by a fifteen minute rest and lunch period in the forenoon and a ten minute rest in the afternoon.

(k) The fifteen minute stretches showing highest outputs are evenly scattered throughout the day with the exception of the beginning and end of the work periods. They are evenly distributed over the days of the week,

(l) If the greatest fifteen minute output ever obtained by each operator is used as an index of her maximum speed it is found that during the "no rest" period No. 12 the operators maintained an average speed throughout the day which was equivalent to 64% to 72% of their maximum possible outputs, while during the "morning lunch, afternoon rest, and 4:00 o'clock stop" period No. 8, their average daily outputs were equivalent to 80% to 84% of their maximum possible output.

(m) The physical condition of the operators under test has not been lowered.

(n) The changed working conditions have resulted in creating an eagerness on the part of the operators to come to work in the morning.

(o) Outside influences tend to create either a buoyant or a depressed spirit which is reflected in production. Evidence of this effect is to be found in the comments and experience of individual operators.

(p) Such improvement in general physical conditions as may have developed has been so gradual that no distinct or unusual reflections in the performance can be noted as a result of this improvement.

(q) The earnings constitute only a fraction of the incentive.

(r) An appreciable increase in output took place when the test room operators were put on special gang pay basis and were no longer paid with the large gang.

(s) Important factors in the production of a better mental attitude and greater enjoyment of work have been the greater freedom, less strict supervision and the opportunity to vary from a fixed pace without reprimand from a gang boss.

(t) The operators have no clear idea as to why they are able to produce more in the test room; but, as shown in replies to questionnaires in appendices B and C of the report of August, 1928, there is the feeling that better output is in some way related to the distinctly pleasanter, freer, and happier working conditions.

(u) The outcomes of the test room experiment seem to indicate that much can be gained industrially by carrying greater personal consideration to the lowest levels of employment.

3. The Importance of Considerate Supervision

The probability that the improved mental attitude of these operators has been an important factor in their increased output makes it seem worth while to give further consideration to this problem at this point.

As far as the upper levels of employment are concerned, industry generally recognizes the following three conditions, which are based upon biological principles:

(a) It is recognized that the emotions affect health. Not only have Pavlov, Cannon, and others shown the effect of fear, anxiety, worry, and other emotions upon the digestion and the general health, but it is common experience that worry, unhappiness, and frustrated efforts are more potent factors in breaking down the individual than an excess of hard work at which one is eminently successful.

(b) Variation in output is natural. One is not at his best every day. One does not work equally fast all day long. An off day once in a while is to be expected.

(c) It is believed that in the long run output will largely depend upon the mental and physical state of the individual. Preoccupation, caused by physical ills or unhappy mental states, is an arch-enemy of production.

The acceptance of these general principles has made industry for the men at the higher levels, a pleasant, co-operative, friendly, and interesting activity. To be sure, competition still exists and attention is given to individual production; but this does not injuriously affect the emotions. A man enjoys a fair race with a clear track ahead and encouragement along the way.

Yet, while industry has given important consideration to these biological and human principles when dealing with the higher levels of employment, it may properly be asked whether these same principles have been applied at the lower levels of employment, and, if not, whether they are applicable.

Perhaps unconsciously industry may have made two fallacious assumptions:

First, it seems to be a general assumption by people everywhere that emotional reactions are of minor importance among those of limited mental scope. The parent thoughtlessly denies the child some harmless thing which seems unimportant to the father, but which is all-important to the son. There is a difference in values. The parent rebukes the child in the presence of the boy's play fellows and social equals. It is an unimportant incident to the father, but the child may always carry the personality scar. The gang boss often tries to live up to his title, when he ought to be a group supervisor. He assumes that the gang are thick-skinned and that his thrusts must go deep. It is characteristic for people to feel the importance of severity and discipline when they first assume authority. The soldier may occasionally fail to salute a colonel without reprimand, but woe to him if he "passes up" a second lieutenant.

As a matter of fact, emotions are stronger and minor matters of greater importance among those people whose horizons are limited and whose interests are few. Recognition by one's superior, a minor success, and a word of encouragement mean more to such people than to the self-reliant mental giant. An operator in the test room recently had a birthday. The girl who sits beside her got up early enough in the morning to make a cake for her and get to work at 7:30. Measured in money value the gift was trivial. Measured in personal effort it was greater perhaps than any gifts which might be exchanged amongst those in the higher levels of employment.

The whole point is that the average employee at the bottom of the industry is keenly sensitive in matters of human relationship. Why is there failure to recognize this? Perhaps the attitude inherited from the beginnings of the factory period, which were surrounded by class distinctions and a lack of understanding of the human mind which should have been left behind has not been outgrown. Moreover, the emotion of fear - fear that we may be laughed at for considering a thing so intangible as the human emotions - often keeps us from giving due consideration to this problem. Emotions exist and business management must be unemotional enough to consider with coolness and candor their place in the organization of working conditions.

Second, there is also the common assumption that consistency of output is desirable and may be obtained through discipline. Neither phase of this assumption has been proved. If consistency of production is demanded, the worker must in self-protection make sure that the maximum output figure is kept low enough so that he can consistently approximate it. Industry would not think of demanding consistency of performance through discipline in the higher levels of employment in the way that this end is sought at the lower levels.

There is, perhaps, greater need for the recognition of the three principles previously mentioned and their application at the lower levels of industry than at the higher levels.

SECTION VI

BIBLIOGRAPHY

Baumberger, J. P. - "Fatigue and Error in a Mental Occupation", Journal of Industrial Hygiene, Vol. III.

Bedale, E. M. - "Comparison of the Energy Expenditure of a Women Carrying Loads in Eight Different Positions", Report No. 29 of the Industrial Fatigue Research Board, London.

Emmons, A. B. and Goldthwaite, J. E. - "A Work Chair", Journal of Industrial Hygiene.

Field, L. F. - "The Problem of Fatigue", Industrial Management, Vol. 58.

Fish, F. P., Hood, F. C., Alexander, M. N. - "Rest Periods for Industrial Workers", Research Report No. 13, National Industrial Conference Board.

Frankel, L. K., Fleisher, Alexander - "The Human Factor in Industry" Macmillan.

Gilbreth, Frank B. - "Unnecessary Fatigue", Journal of Industrial Hygiene, Vol. I.

Goldmark, Josephine, Hopkins, Mary D., Florence, P. S., Lee, F. S. - "Comparison of an Eight-Hour Plant and a Ten-Hour Plant", Public Health Bulletin No. 106.

Hackett, J. D. - "Health Maintenance in Industry", published by A. W. Shaw Company.

Hope, E. W., Hanna, W., Stallybrass, C. O. - "Industrial Hygiene and Medicine", William Wood and Co.

Jones, D. C. - "A First Course in Statistics", G. Bell & Sons Ltd., Lond.

Lee, Frederic S., Vanbuskirk, J. D. - "An Examination of Certain Proposed Tests for Fatigue", American Journal of Physiology, Vol. 63.

Lee, Frederic S. - "The Human Machine and Industrial Efficiency", Longmans Green.

Link, Henry C. - "A Practical Study in Industrial Fatigue", Journal of Industrial Hygiene, Vol. No.

Mather, William - "The Forty-eight Hour Week"

Mayers, May R. - "Fatigue in the Washing Departments of the New York Steam Laundries", Journal of Industrial Hygiene, Vol. VI.

Orenstein, A. J., Ireland, H. J. - "Experimental Observations Upon The Relation Between Atmospheric Conditions and the Production of Fatigue in Mine Laborers", Journal of Industrial Hygiene, Vol. IV.

Polakov, Walter N. - "Fatigue and Industrial Efficiency," Industrial Manual, Vol. 58.

Ryan, A. H. - "The Quantitative Measurement of General Fatigue," American Journal of Physiology, vol. 45.

Sanders, A. W. - "The Human Side of How to do it Best," Journal of Industrial Hygiene, vol. VII.

Shepard, George H. - "Fatigue Tests at Purdue University," Industrial Management, vol. 63

Spaeth, Reynold A. - "The Prevention of Fatigue in Manufacturing Industries," Journal of Industrial Hygiene, vol. I.

Spaeth, Reynold A. - "The Problem of Fatigue," Journal of Industrial Hygiene, vol. I.

Vernon, H. M., Jones, W. N. - "An Investigation of the Factors Concerned in the Causation of Industrial Accidents," Health of Munition Workers Committee, Memorandum No. 21.

Vernon, H. M., Vernon, M.D. - "Five Hour Spells for Women, with References to Rest Pauses," Report No. 47, Industrial Fatigue Research Board, London.

Vernon, H. M. - "Statistical Information Concerning Output in Relation to Hours of Work with Special Reference to the Influence of Sunday Labor," Health of Munition Workers Committee, Memoranda Nos. 12 and 18.

Vernon, H. M. - "The Influence of Hours of Work and of Ventilation on Output in Tinplate Manufacture," Report No. I, Industrial Fatigue Research Board.

Vernon, H. M. - "The Influence of Rest Pauses and Changes of Posture on the Capacity for Muscular Work," Report No. 29, Industrial Fatigue Research Board, London.

Vernon, H. M., Bedford, T. - "The Influence of Rest Pauses on Light Industrial Work," Report No. 25, Industrial Fatigue Research Board, London.

Wyatt, S. - "Notes on an Experiment on Rest Pauses," Report No. 25, Industrial Fatigue Research Board, London.

Wyatt, S. - "Rest Pauses in Industry," Report No. 42, Industrial Fatigue Research Board, London.

Wyatt, S. - "Studies in Repetitive Work with Special Reference to Rest Pauses," Report No. 32, Industrial Fatigue Research Board, London.

APPENDIX A*

BEGINNING OF TEST AND ESTABLISHMENT OF TEST ROOM

A. Location of Test Room and Reasons for Selection.
B. Equipment of Test Room and Design of Equipment.
C. Test Conditions Differ from Regular Work Conditions.

The test began on April 25, 1927. The relay assembly job was selected as the one on which the initial study would be conducted, as it represents a high degree of repetitive work. Five operators experienced on this work were chosen, together with a sixth to act as a layout operator. This group was permitted to remain in the regular department from the beginning of the test, April 25, 1927, and until May 10, 1927, at which time the Test Room was equipped and in readiness.

A. Location of Test Room and Reasons for Selection

The Test Room is located in the southeast corner of Building 47-5, and was formed by inclosing two sides with temporary board partitions. In selecting this location it was felt that better ventilation could be had since the room was equipped with fans, and because it would not be exposed to the afternoon sun during the summer months. The lighting effect in the Test Room is approximately equivalent to the light in the Relay Assembly Department, except that the distribution is more uniform. This is made possible by the use of lighting fixtures used in a former Illumination Study which were left in this room.

The location was also chosen as it afforded a better opportunity for segregation because the operators would not come in constant and direct contact with the main group, thereby reducing the possibilities of the test group keeping familiar with the activity of the main group, and thus reducing the tendency of similarity of performance.

B. Equipment of Test Room and Design of Equipment

A regular assembly bench of sufficient length to accomodate five positions and include space for the layout operator was installed. Each of the five assembly positions was connected to a recording device so that each time an operator finishes an assembly or completes a cycle, it is automatically registered by an electrical recorder perforating a hole in a moving tape. The perforating mechanism is selective and each operator's respective position is therefore positive, as the operators occupy the same bench position at all times.

*Sections II, III and IV of previous report.

In addition to the assembly bench there are three other small benches upon two of which the recording apparatus is mounted, and the third serves as a stock bench for piece parts. A table, file cabinet, and drafting table comprise the rest of the equipment with the exception of the recording devices which are described in the following paragraphs. A comprehensive view of the Test Room is shown in Photographs No. 155739 and No. 155740, forming a part of this chapter.

A hole has been cut in the bench to the right of each operator's position sufficiently large to accomodate the passage of a relay. When the relay is dropped through this hole it passes into a chute mounted at a 45° angle to the bench, passing by and operating a "flapper" gate or switch and on out into the receptacle. The gate is attached to an axis which extends through the side of the chute. A cam is attached to that portion of the axis extending beyond the chute and this cam when operated engages contact springs, thereby closing a circuit and operating the recording perforator which punches a hole in the tape traveling across the mechanism.

The perforating recorder proper consists of a perforator for the printing telegraph modified to meet the conditions of the test in that the circuit from each operator's position is connected to a respective coil in the perforator which operates the recording punch associated with that position. A view of this apparatus is shown in Photograph No. 149583.

The travel of the tape through the perforating recorder is accomplished by means of a 110-V A.C. motor of a 1/6 H.P. rating, connected through proper gears to friction rollers through which the tape passes. These friction rolls pull the tape through the recording device at a definite speed of 1/4" per minute.

In the circuit of the perforating machine a set of five message registers has been included. These registers correspond to the five rows of perforations in the tape, and are therefore selective for each assembly position. Each register functions when the corresponding coil in the perforating device is actuated, and therefore, provides accumulative totals of relays assembled at the particular assembly position to which the register is connected. The advantage of these registers is that a ready means is provided whereby a direct reading of each operator's output may be had for any period.

An automatic temperature and humidity recorder was used for a period to keep a graphic record of atmospheric conditions; however, operating difficulties minimized the advantages to such an extent that this machine was abandoned in favor of the Hygrodeik from which hourly temperature and humidity readings are made.

C. Test Conditions Differ from Regular Work Conditions

The equipment for the assembly of the relays is practically the same as in the regular shop. The greatest variance is that a hole has been provided for each operator into which the finished work is deposited, instead of having to replace it in the compartment boxes from which the coils have been taken.

The conditions surrounding the test are the principal differences. These are the segregation features and the more uniform distribution of day light, as the day light value is much higher since the building in which the test is being conducted is equipped with full sectional width sky lights. Besides these, there is the absence of customary supervision, less interruption due to changing of jobs, visiting, etc. In addition to the material and physical differences, there are the mental or psychological differences which obviously would surround a group of people selected for such a test.

UNIVERSITY OF WISCONSIN - MILWAUKEE

UNIVERSITY OF WISCONSIN - MILWAUKEE

UNIVERSITY OF WISCONSIN - MILWAUKEE

METHOD OF RECORDING OUTPUT DATA

A. Reading of Message Register Record and Perforated Tape.
B. Records Taken for Average Hourly Outputs.
C. Pertinent Records.
D. Uniformity of Performance.

Considerable attention has been given the recording of output, since with adequate and correct records any short periods as well as longer periods, may be selected for separate study.

A. Reading of Message Register Record and Perforated Tape

During the course of the study, readings of the message registers are taken at half-hour intervals. The figures are entered upon a form and when not immediately used in plotting curves are filed for future reference.

The perforated tape is being used in obtaining the exact output during the fifteen-minute intervals and this is done by counting the number of perforations. Before the tape or perforations are counted, it is necessary to make an exact division of each fifteen-minute interval. Since, as previously mentioned, the speed of the tape through the perforating machine is 1/4" a minute, it is obvious that a distance of 3-3/4" represents a fifteen-minute interval. The tape is then divided into intervals of 3-3/4", and the number of perforations in these intervals is counted. This number is an accurate record of the total relays assembled during that period. There is a slight variation in the length of the tape from day to day. This variation, however, is compensated for when the tape is divided into intervals.

In counting the number of perforations in each fifteen-minute section, care is used in determining how close the first or last perforation comes to the sectional markings. In this way it is possible to divide the fractional portions of partially completed cycles, and record the nearer correct number in each interval.

The outputs thus obtained are converted to a common basis. This is necessary as the schedules of the various types assembled are not sufficient to permit continuous performance on any one type, and the operators at times are forced during one day's run to work on more than one type. This sometimes causes a fluctuation in the output as some types require a different length of time to assemble than others.

Daily curves may be plotted on the basis of these outputs over fifteen-minute intervals for each operator. The curves give a picture of the variation in rate of production at any hour of the day and from them it is possible to select the periods of lessened or increased activity on a very definite basis, and to determine at what periods rest pauses should be introduced in order to be most effective. The curves also bring out any improvement in regularity of performance from day to day as various experiments, such as rest pauses, are tried out.

B. Records Taken for Average Hourly Outputs

Records of the total daily output of each operator and the corresponding total operating time are kept. The outputs are converted to a common basis and an average hourly output for the day is determined.

Continuous curves are plotted from these data for each operator and a combined curve showing the average performance of the whole group is maintained. These curves show the progress, in so far as average production is concerned, of the individuals and of the group over the periods of the experiments and they also present a ready means of comparing the performance of one period against another.

C. Pertinent Records

Other records pertinent to the test and of value as an aid in interpreting results and psychological effects are maintained as follows:

1. The temperature and relative humidity, which are recorded each hour and then averaged, are plotted on the daily average hourly output curve.

2. A complete report of the daily happenings (History Sheets) of the test is made and this records what changes are made; what transpires during the day; operators' remarks; our own observations; and anything that will assist as an explanation when rationalizing the performance curve.

3. A "Log Sheet" is maintained on each operator upon which her starting and finishing time is entered, and the time at which changes from one type to another are made; also all intervals, or non-productive time, such as, personal time out, changes in type, repairs, and anything detracting from the actual production time.

4. An original hospital report, or record of physical examination, is kept. This has been supplemented each time the group is re-examined, which occurs periodically every five or six weeks. In this

record an attempt has been made to classify each operator, giving her a definite place in the list according to her physical fitness, reactionary tendencies, etc.

5. An attempt was made to discover the home and social environs under which each girl lives. A set of questions was prepared and answers were obtained to as many of these as possible.

6. Data have been gathered in the attempt to reflect what in the judgment of the operators themselves is the reason why they do better work under Test Room conditions. This record, together with the records outlined in paragraphs 4 and 5, is used in determining to what extent the more personal elements influence the individuals' activities and output.

D. Uniformity of Performance

In order to determine the effects on uniformity of performance resulting from the various features tried out, a system of obtaining and recording these data has been worked out as follows:

When the tape has been divided into the fifteen-minute intervals, and these intervals counted and recorded, they are changed or corrected to be comparable to the type of relay which had the longest run on the particular day being considered. By doing this, the intervals all become consistent in their relation to each other. The average output on the basis of fifteen-minute intervals is then obtained. This is arbitrarily taken to represent ideal performance, and which obviously would have produced the same total output provided it were actual.

Since it is hardly to be expected that ideal performance can be maintained where the rate of output depends approximately one hundred per cent on the individual's efforts, it was decided to consider a variation of plus or minus one relay from the theoretical average as being representative of ideal performance. This was done, and upon the plotted curves a line representative of the average was drawn. Two other lines were then drawn, one above the average line, to represent the plus-one relay allowance, and one below, to represent the minus-one relay allowance. This arrangement produces a band or field of relatively ideal performance and any points of the curve falling outside of this arbitrarily established field are counted, and an index of the total variation for any operator for any day or division of a day is thus obtained.

A further advantage is gained by this method in that it permits of the extent of the variation to be shown singly, i.e., the total

variation on the plus side of the band or the total variation on the minus side of the band may be seen, as well as the grand total for the day.

The figures representative of this variation are tabulated for each operator daily and are then totaled at the conclusion of a specific period. The average variation for any particular period is then obtained from which the value of the period in terms of uniformity of performance may readily be seen. By this system fluctuations as small as one-tenth of one relay are included in the total, which directly represents the increased or decreased amount of fluctuation in the rate of working.

As an expedient, however, the uniformity of performance curves are plotted direct from the data and the actual plotting of the fifteen-minute interval curves is done only when it is desired to know the trend of the daily production.

METHOD OF PAYMENT

Under regular operating conditions the work which was selected for the test is done by one large gang, the individual members of which share proportionarly in the earnings of the gang as a whole. The operators selected for the test were members of this large gang. Under this system individual effort is not always actually recognized or rewarded to the fullest extent; also no definite figures on individual outputs are kept.

For the purpose of the test it was necessary that it be known what each of the assembly operators selected was capable of doing in the way of daily outputs, and it was also desirable that some method of payment should be introduced which would pay each one in direct proportion to her efforts while on test. It was felt that, unless the latter were done, the operators would not respond with the fullest cooperation that would be essential to a test of this nature.

Also, it was necessary that the operators should feel assured that they would not suffer financially in any way as a result of their participation in the test. They were told, then, that a method of payment would be introduced after the test was well under way, which would assure them earnings equal to what they had been getting in the past, with the possibility that these earnings would actually be increased should their outputs obtained in the Test Room increase over those obtained in the regular gang.

For two weeks previous to the start of the test, accurate records were kept of the individual outputs of the operators while working under the normal conditions of operation in the regular department. These records gave a picture for use as a basis of comparison with later results and also made it possible to establish piece rates for use in the Test Room.

The average earnings of the operators used in the test were computed by totaling the hourly piece work earnings for March, April, and May, 1927, as shown on their respective attendance records. During this period the operators averaged $.553 an hour or 64.66% earnings over their average hourly day rate. These average hourly earnings were increased 23.8% as an allowance to cover the rate of the layout operator who participates in the earnings but who has no direct output. This allowance brought the average hourly rate which must be earned by each assembly operator up to $.686. Thus, piece rates figured to return earnings of $.686 an hour on the basis of average outputs would permit all the operators in the gang to make earnings of 64.66% over their hourly day rate.

The total outputs of each type of relay assembled during the two weeks previous to the start of the test were reduced to an average hourly basis which, when divided into $.686 gave a piece rate to be used for that particular type in the Test Room.

It should be mentioned here that the types assembled just previous to the start of the test were the ones selected to be run in the Test Room so far as possible.

The rates figured as above were checked by applying them against the outputs obtained for the two weeks previous to the test, and the results showed that the earnings returned would be on the basis desired. This was done to prove the adequacy of the proposed rates before putting them into effect.

After the start of the test, the operators worked for five weeks in the Test Room under exactly the same conditions as those in effect in the regular gang. They used the same piece rates as were in effect and shared in the earnings of the whole group as formerly. This was done to enable them to become thoroughly familiar with the new conditions and surroundings before introducing any changes whatever.

At the end of the five-week period, the new piece rates were introduced and the Test Room group was separated into a special gang to be paid on the basis of earnings obtained from the piece rates effective for the Test Room work only. This was done in order that the entire earnings resulting from their efforts would be returned directly to them and not distributed over a large number of people. By these means we were able to easily convince the operators that any gains in output would be returned entirely to them and we were thus reasonably assured of their full cooperation.

APPENDIX B*

FACTORS AFFECTING OUTPUT BUT EXTERNAL TO THE CHANGING CONDITIONS OF THE EXPERIMENT

A. Seasonal Variation
B. Vacations and Practice Effect

A. SEASONAL VARIATION

In order to determine the existence or absence of general seasonal fluctuations in the output rate, two sets of data were examined. There were (1) the percentage earnings of the whole group of approximately fifty-five hundred gang piece work operators for a three-year period expressed as a percentage of the base rate, and (2) the output of a small group of assembly operators for one year beginning March, 1927, expressed as a percentage of the bogey. In the latter case twenty-nine operators were selected from an examination of the bogey book and the elimination of operators whose record showed changes in the bogey, illness, and extended absence during the period under investigation.

The results of this study may be read directly from the accompanying chart to which average monthly temperatures have been added. The chart shows two things clearly: (1) A general upward trend in the production rate during the period under examination; and (2) a definite seasonal variation during the year, producing a two-hump curve with high points in the spring and fall and low points in mid-summer and mid-winter. The individual yearly variations, and hence the average variation, are consistent in the type of seasonal fluctuation shown. The fluctuations are not extreme but are worthy of consideration in interpreting the data of this experiment.

The interpretation of this seasonal fluctuation is not entirely easy. The average monthly temperatures which are given on the chart show that the fluctuation is not directly and entirely a function of temperature. Obviously humidity and sudden changes in temperature, as well as the dry bulb temperature itself, would be factors in determining output. Other factors which may influence the vitality of the worker are seasonal changes in the amount of sunlight, changes in the diet due to the materials available in the market, and changes in activities outside of factory hours.

An examination of the curves shows that the lowest production is in the summer and the highest production in the fall. January is always the low point in the winter slump but the low point in summer production may be in June, July, or August. Production usually reaches its fall peak in November and its spring peak in April or May. While the curves do not closely follow the temperature the fluctuation is so consistent as to indicate that extremes of temperature in either direction are disadvantageous. The upper critical point seems to be somewhere between 60° and 70°, and the lower critical point between 25° and 30° F. When the

* Section X of previous report.

average temperature moves far beyond either of these critical points production definitely drops. It is to be expected that the movement of the curve showing weekly output for twenty-nine operators would be more variable than the curve showing production for the large group of assembly operators.

B. VACATIONS AND PRACTICE EFFECT

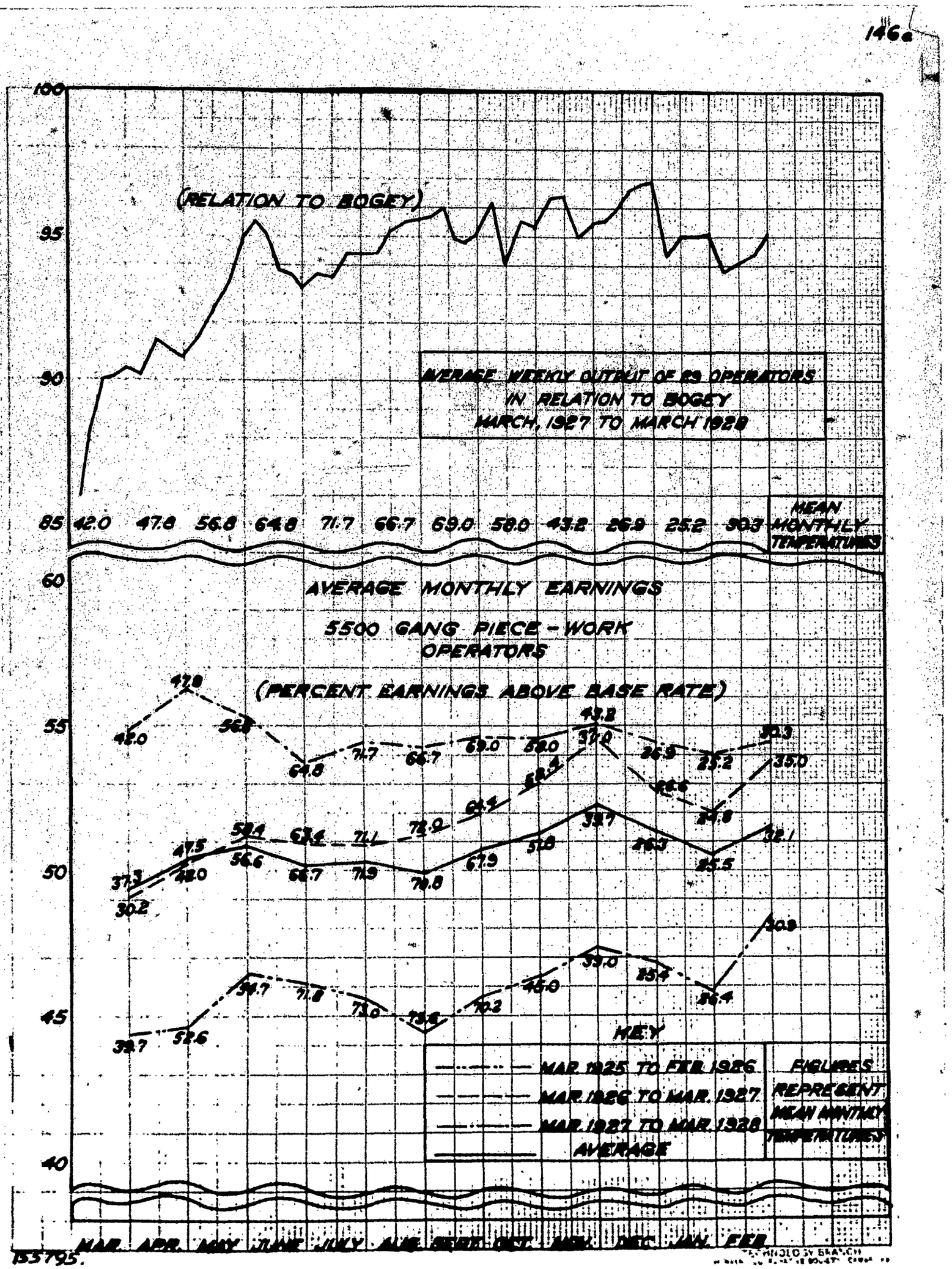
The examination of the bogey book showing the output of individual operators during the year from March, 1927, to March, 1928, showed that many operators had an unusually low production for the week following their vacation. Comparative data were drawn off from this book showing the production of one hundred twenty-one operators for the week before their vacation and for the week after. The results of this computation are shown on the following sheet.

Sixty-nine of these operators had a one-week vacation and it will be seen that their output for the week following vacation was practically identical with their average output for the week preceding vacation.

Fifty-two of the operators received a two-week vacation. The following table shows that their production, in terms of a percentage of the bogey, was 2.9% less the week after vacation than the week before. The standard deviation of the difference is 1.51. The probable error of the difference is 1.02.

The interpretation of the reliability of this average drop in production by statistical comparison of the average difference with its standard deviation and probable error shows a probability of ninety-seven chances in one hundred that the average production of all operators would be somewhat less the week following a two-week vacation than the week before.

This limited study is, therefore, not conclusive but shows the high probability that such a difference exists. Should further data confirm this finding, it would seem that a two-week vacation period produces a physical condition or a "lack of practice" which causes the worker to work at a slightly lower rate when first resuming work.



153795.