

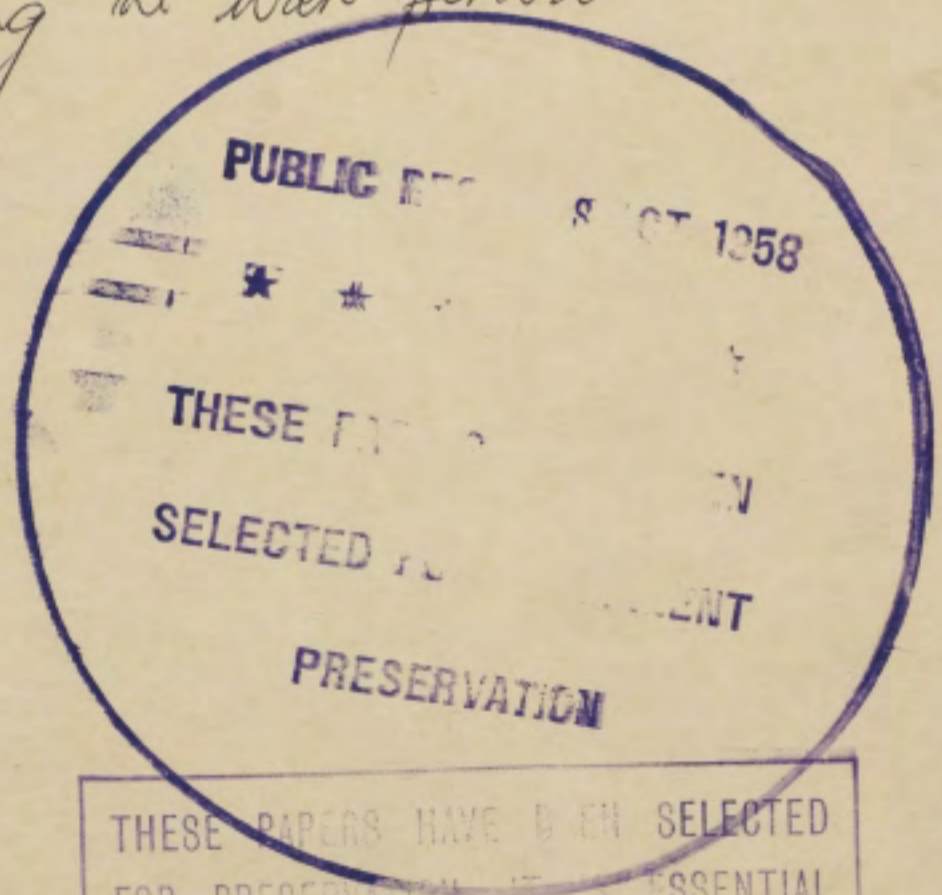
ENGLAND

Box 30 / 4304 A

4551

1919

Engineer in Chief's Department  
Sir William Slingo's Report on work  
during the war period



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**GENERAL POST OFFICE.**

SUBJECT.

ENGINEER-IN-CHIEF'S DEPARTMENT.

Sir William Slingso's Report on work during the period of  
the War.

*Heac*

PRÉCIS OR INDEX OF PAPERS IN FILE.

116 JAN 1959

Submit to Pres

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Mem: The Staff Beh have  
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with papers 128,589/19

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26 viii '19

10 JUN 1919.

ENGLAND.

*Confidential*



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FLAT

The Postmaster General,

Min. No. 7551 1919.

Date June 1919.

Regd. No. \_\_\_\_\_ 19

Letter to \_\_\_\_\_ 1919.

*Subject.*

I submit a very interesting Report from Sir William Slingo as to the work of the Engineering branch of the Post Office during the period of the War. The first section deals with special War work and the second with the ordinary working of the Post Office Telegraph and Telephone Services.

ENGINEER-IN-CHIEF'S DEPARTMENT.

Sir William Slingo's Report on

work during the period of the War, with the ordinary working of the Post Office Telegraph and Telephone

Services.

*W. P. Price  
W. Slingo*

*Ans*

June 1919.

*A.H. 71  
26/6/19*

14.9.19  
27.6.19

114055

CONFIDENTIAL.

R E P O R T

on

WORK OF THE ENGINEERING DEPARTMENT  
DURING THE FIVE YEARS COVERING THE  
WAR PERIOD 1914-1919.

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initiation and control as it exercises with respect to supplies for its own use.

Schedules marked Appendix H detail the principal items designed, manufactured and supplied.

CABLES.

43. Owing to the unsuitability of Military field cables for trench communications, the Director of Army Signals, France, consulted the Department early in the War regarding the supply of light armoured cable. At that time the lightest type of armoured cable stocked by us weighed two tons per mile. A twin armoured cable was therefore designed, weighing 430 lbs to the mile and having gutta percha as an insulating covering, which proved quite satisfactory. Other types of armoured cables were designed from time to time as the trench warfare developed, and the demands have been such as to keep several Cable Factories working continuously night and day. The following list shows approximately the quantities of the various types of trench cable supplied:-

	<u>Miles</u>	<u>Weight per mile.</u>
G.P.Twin Armoured	8,250	430lbs.
G.P.Twin Brass sheathed	600	210 "
G.P.Quad Armoured	12,000	700 "
G.P.Quad Brass sheathed	4,000	290 "
G.P.Twin Concentric		
Armoured	1,280	280 "
Enamld. & G.P.Twin Armoured	3,750	260 "
"    "    "    7pr/10    "	1,250	1,300 "
"    "    "    7pr/10 Brass		
Sheathed	3,250	900 "
India Rubber Twin Armoured	7,000	520 "
"    "    Quad    "	100	600 "
"    "    "    Cab tyre		
sheathed Armoured	1,300	480 "
Enamld. & Cotton Covered		
"    "    "    4pr/10	850	1,008 "
"    "    "    7pr/10	1,300	1,300 "
"    "    "    7quad/10	10	1,540 "
<u>Total,</u>	<u>44,920 miles of cable,</u>	<u>with</u>
		single conductor mileage of practically 200,000.

In addition and for other purposes, about 900 miles of lead sheathed paper core cable, representing

a single wire mileage of over 22,500 miles, were provided for the Armies abroad and for Aircraft Defence Works in this country. Its special feature was the outside serving of tape impregnated with pitch which protected the sheathing and enabled the cable to be laid safely underground without pipes or troughing.

Special methods of jointing these cables were also devised by my Officers.

Aerial cable to the extent of 1300 miles, and having a single conductor mileage of 16,200 miles, were sent out including several new types, such as 10, 12, and 20 wire cable, having an internal steel wire strand and sheathed with specially tough rubber to enable the cable to be suspended in long spans and to withstand severe conditions.

44. During the first year of the War 1200 creosoted poles were released from our stock to supply Army demands, and arrangements were also made for supplying approximately 46000 home grown untreated poles which were slotted and earth wired in this country. Afterwards the Timber Supplies Committee undertook the supply of poles and arms for the Armies in France. POLES AND  
LINE STORES.

Considerable work has been involved also in devising special types of insulators, spindles, arms, arm grips, pole steps, brackets, cable hangers, etc. and in arranging for numerous modifications of the P.O. standard specifications to facilitate and cheapen the manufacture of the large quantities required.

In the Autumn of 1918, during the Allied advance, the difficulty which was being experienced in obtaining sufficient Hard Drawn Copper Wire was brought to my notice, and I was able to suggest various relaxations in the tests prescribed in the standard specification for wire which materially assisted the Manufacturers and correspondingly increased the output. In order to get the best possible

I N D E X.

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A. ENGINEERING WORK CARRIED OUT IN CONNECTION WITH THE WAR.

SUBMARINE CABLES.

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1. Cutting of German Cables (August 1914)</p> <p>2. Cable system for Grand Fleet at Orkney, etc.</p> <p>3. Emergency Cable Depot at Plymouth.</p> <p>4. Special Submarine Cables provided during the War.</p> <p style="padding-left: 20px;">(i) Dunkerque-Cherbourg Cable (Sept. 1914)<br/>Cherbourg-Brest Cable (Sept. 1914)<br/>Dartmouth-Jersey Cable (Oct. 1914)</p> <p style="padding-left: 20px;">(ii) St. Margarets-Dunkerque Cable (Oct. 1914)</p> <p style="padding-left: 20px;">(iii) Jersey-St. Malo Cable (Sept. 1914)</p> <p style="padding-left: 20px;">(iv) Birling Gap-St. Nazaire Cable (Sept. 1914)</p> <p style="padding-left: 20px;">(v) Anglo-Russian Cable (Jan. 1915)<br/>Duplicate equipment at Alexandrovsk (Oct. 1916-March 1917)<br/>Duplicate equipment at Peterhead (August 1917)</p> <p style="padding-left: 20px;">(vi) Additional Cables in the White Sea (August 1917)<br/>Repair of faults in Kola Inlet (Summer 1918).</p> <p style="padding-left: 20px;">(vii) Dungeness-Audrecelles No. 1 Cable (January 1916).</p> <p style="padding-left: 20px;">(viii) Dover-Dunkerque Cable (Jan. 1917)</p> <p style="padding-left: 20px;">(ix) Dover-Sangatte Cable (Aug. 1917)</p> | <p>(x) Cuckmere-Havre No. 1 cable (Sept. 1917)</p> <p>(xi) Cuckmere-Havre No. 2 cable (Feb. 1918)</p> <p>(xii) Dungeness-Audrecelles Nos. 2 &amp; 3 cables (May 1918).</p> <p>(xiii) Anglo-French Emergency Cable (1918).</p> <p>(xiv) Dover-Sangatte No. 2 cable (November 1918).</p> <p>5. Atlantic Cables Scheme (Dec. 1916 onwards).</p> <p>6. Recovery of German Cable in Channel (Nov. 1918).</p> <p>7. Cable Repairs.</p> <p>8. Working Parties.</p> <p>9. Cable work for Anti-Submarine Department of Admiralty (Dec. 1917-Nov. 1918).</p> <p>10. Dangers connected with the work.<br/><br/>Loss of "Monarch" (Sept. 1915).<br/>Accident to "Mersey" (March 1918).</p> <p>11. Staffing of Cable Fleet.</p> <p>12. Control of Cable Manufacture.</p> |
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HOME DEFENCE.

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>13. Design of Home Defence Installations.</p> <p>14. P.O. Advisers to G.O. Cs, Home Forces.</p> <p>15. Gun Stations.</p> <p>16. Circuits for observation of fire.</p> <p>17. Heightfinders.</p> <p>18. Searchlights.</p> <p>19. Aircraft Defence &amp; Warning Control Headquarters.</p> <p>20. Observer Posts.</p> | <p>21. Aerodrome, Acceptance Parks, Squadron Hqs. etc.</p> <p>22. R. A. F. Aeroplane Observation School.</p> <p>23. Admiralty Telephone Equipment.</p> <p>24. G. H. Q. Horseguards Telephone equipment.</p> <p>25. G. H. Q. Horseguards Telegraph Office.</p> <p>26. Military &amp; Naval circuits, security of route in London.</p> <p>27. C. T. O. Air Raid Emergency Schemes.</p> |
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| <p>28. Alternative London Trunk Exchange for important circuits.</p> <p>29. Provincial Centres, restoration of communication.</p> <p>30. Emergency Lighting at Telephone Exchanges.</p> <p>31. Air Raid Warning Circuits to Munition Factories, etc.</p> <p>32. Underground Works at vulnerable points.</p> <p>33. Training Centre for A.A. personnel.</p> <p>34. Protected Apparatus at Naval Airship Stations.</p> | <p>35. Emergency Schemes.</p> <p>36. Kent Emergency Scheme brought into use.</p> <p>37. Kent Coast Defence Scheme.</p> <p>38. Enlistment of P.O. staff for co-operation with R.E. Signals for Home Defence.</p> <p>39. Long Distance Circuits for War Department, Admiralty, etc.</p> <p>40. Branch Exchanges for War Department, etc.</p> <p>41. Number of Emergency Works carried out for Government Departments.</p> |
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APPARATUS AND CABLE SUPPLIES.

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|------------------------------------------|------------------------------------------------------------------------------------------------------|
| <p>42. Apparatus.</p> <p>43. Cables.</p> | <p>44. Poles and line stores.</p> <p>45. Examination of apparatus and stores for War Department.</p> |
|------------------------------------------|------------------------------------------------------------------------------------------------------|

RADIO-TELEGRAPHY.

- |                                                                                                                                                                                       |                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>46. War Measures under Defence of the Realm Act.</p> <p>47. Search for illicit signals.</p> <p>48. Interception of enemy signals.</p> <p>49. Wireless School for Flying Corps.</p> | <p>50. Direction Finding Stations.</p> <p>51. New type Direction Finding Gear.</p> <p>52. Ship and shore work.</p> <p>53. Substantive circuit connections between Wireless Stations.</p> |
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RESEARCH.

FOR WAR OFFICE.

- |                                                                                                                        |                                                                                                           |
|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| <p>54. Sound Ranging.</p> <p>55. Hypersensitive Telephone Transmitters.</p> <p>56. Special Apparatus for Military.</p> | <p>57. Palestine Train Signalling System.</p> <p>58. Experiments and tests with Signalling Apparatus.</p> |
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FOR ADMIRALTY.

- |                                                                                                                   |                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>59. Apparatus for use in Marine Mines.</p> <p>60. Signalling through sea.</p> <p>61. Submerged Electrodes.</p> | <p>62. Experiments with Amplifiers.</p> <p>63. Submarine Hunting Research for Anti-Submarine Division.</p> <p>64. Electro-magnetic induction devices.</p> |
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FOR AIR FORCES.

- |                                                                                                   |                                                                  |
|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| <p>65. Aircraft Magneto Ignition Machines.</p> <p>66. Microphones for Anti-Aircraft Research.</p> | <p>67. Air Ship Telephones.</p> <p>68. Aeroplane Telephones.</p> |
|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------|

- 69. Kite Balloon Telephones.
- 70. Steering Indicators.
- 71. Low Temperature and Secondary Cells.

- 72. Tank switchboard.
- 73. Aircraft Oscillograph.
- 74. Testing apparatus.
- 75. Letters of appreciation.

GENERAL.

- 76. Early precautionary measures.
- 77. Expenditure.
- 78. Contracts.
- 79. Enlistment of Engineering Staff.
- 80. Economy in Clerical Work.
- 81. Maps and Plans.
- 82. Instruction of Signallers for new Armies by P.O. Instructors.
- 83. Electric Light & Power Work.
- 84. Damage to Engineering Plant by enemy action.
- 85. High Speed and Printing Telegraphs.
- 86. Telephone Repeaters.
- 87. Continuously loaded cables.
- 88. Telephone circuits superposed on single core telegraph cables.

- 89. Special Engineering work at Dunkirk.
- 90. Breakdown of March 1916.
- 91. Dublin disturbances.
- 92. Commander-in-Chief's Mobile Hq.
- 93. Mesopotamia Telephones.
- 94. Assistance to Belgian Admin.
- 95. U.S.A. Army Communications.
- 96. Admiralty Traffic Control circuit, Caledonian Canal.
- 97. Irish Seaplane Station Communication system.
- 98. Royal Irish Constabulary Communication system.
- 99. Visits to France.
- 100. Honours.

B. ENGINEERING WORK, NOT DIRECTLY CONNECTED WITH THE WAR, CARRIED OUT DURING THE WAR PERIOD.

DEVELOPMENT.

- 101. Expenditure on Engineering Programmes.

- 102. Main Lines.
- 103. Local Lines.

WAYLEAVES.

- 104. Crossings over Railways.

- 105. Protection from Power Circuits.

TELEGRAPHS.

- 106. Baudot duplex.
- 107. Murray system.
- 108. Western Electric Multiplex.
- 109. Wheatstone Automatic System.
- 110. Creed system.

- 111. Keyboard Perforators.
- 112. Post Office Standard Relay G.
- 113. Batteries.
- 114. Fire Alarm circuits in Post Office buildings.

115. Telegraph Concentrator  
Switchboards.  
116. Minor Telegraph circuits.

117. Experimental Work.  
118. Committee on High Speed  
Telegraphy.

RADIO-TELEGRAPHY.

119. Imperial Wireless Scheme.  
120. Fleming Patent & Marconi Co.  
121. Ship & Shore Stations.  
122. Stonehaven & Cullercoats High  
Speed Communication.

123. Leaffield Wireless Station.  
124. Wireless Communication with  
Isle of Man during stoppage  
of cable.  
125. Wireless Laboratory.  
126. Experimental work.

✓ TELEPHONES.

127. Automatic Telephones.  
128. New Manual C.B. Exchanges.  
129. New small exchanges.  
130. Exchange Transfers.  
131. Trunk & Local Amalgamation.  
132. Trunks worked as Junctions.  
133. New Pattern Multiple Switchboard  
134. C.B. Private Branch Exchanges.  
135. Telephone-Telegram & Phonogram  
Arrangements.  
136. Operating Schools.  
137. Coin Collecting Boxes.  
138. Call Office Switchboards.

139. C.B. Exchange Power Circuit.  
140. Secondary Cells.  
141. Power Ringing at small Exs.  
142. Small Flash Lamps.  
143. Loose Leaf Diagrams.  
144. Fire Emergency Exchange Eqpt.  
145. Emergency Power Plant for  
Telephone Exchanges.  
146. Fault Procedure.  
147. Transmission Standards.  
148. Loading Telephone Cables.  
149. Telephone Repeaters.  
150. Composite Telegraph and  
Telephone circuits.

POWER, TRANSPORTATION, HEATING, ETC.

151. Post Office (London) Railway.  
152. Power.  
153. Pneumatics.

154. Conveyors and Lifts.  
155. Electric Trucks.  
156. Heating and Ventilation.

RESEARCH.

157. Interchange of Information be-  
tween British and French  
Post Office.  
158. Balancing of Underground Trunk  
Cables.  
159. Aerial Loading.

160. Non-corrodible steel for  
Submarine Sheathing Wire,  
etc.  
161. Submarine Cable containing  
28 wires.

GENERAL.

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|--------------------------------------|-----------------------------------------------------|
| 162. Wire Mileages.                  | 169. Mechanical Transport.                          |
| 163. New Designs.                    | 170. Diversion from City & South<br>London Railway. |
| 164. Apparatus Supplies.             | 171. "Awards" Scheme.                               |
| 165. Joint Examination System.       | 172. Plant tests.                                   |
| 166. Surplus Stocks.                 | 173. Technical etc. instructions.                   |
| 167. Underground conduits, etc.      | 174. Conferences of Superintending<br>Engineers.    |
| 168. Standardisation of Line Stores. | 175. Appreciation.                                  |

APPENDICES.

- A. Schedule of cables laid or provided since the outbreak of War.
- B. Photographs of the Telegraph Construction and Maintenance Company's Cable Ship "Colonia", employed on the Imperial Cable Work, and of various cable operations on board ship.
- C. Schedule of German cable picked up during the War.
- D. Schedule showing lengths of German cable utilised in situ in connection with British and French cables.
- E. List of vessels chartered for Cable Repairs.
- F. List of Cable Ships, Trawlers, etc., (excluding chartered vessels) employed on Submarine Cable work.
- G. Schedule showing number of Emergency Works carried out during the War for the War Office, Admiralty, Ministry of Munitions, National Service Department, and Royal Air Force.
- H. Details of the principal items of Apparatus designed, manufactured, and supplied to the Fighting Forces.
- I. Photographic copy of letter of thanks from Sir Douglas Haig to the Postmaster General in connection with Sound Ranging Research.
- J. Schedule giving approximate cost of War Engineering Work.
- K. Schedule showing the number and estimated value of Contracts placed during the Financial Years 1913-14 to 1918-19.
- L. Graph showing number of Workmen, below the rank of Inspector, employed during the War; the number of Workmen released for Military and Naval Service; and the number of Female Assistants taken on as substitutes.
- M. Schedule showing total numbers of all ranks absent on Naval and Military Service on 1.12.1918, and total numbers demobilised up to 28.3.1919.
- N. Schedule showing numbers of staff of different grades actually employed at 31st March, 1916, 1917, 1918 and 1919.
- O. List of principal items of Map and Plan work carried out during the War.

- P. Chart showing Routes taken by Zeppelins during Raid of 2-3 May 1917.
- Q. Schedule showing Engineering Expenditure during the Financial Years 1914-15 to 1918-19 compared with Parliamentary Grant or Treasury Authority.
- R. Schedule of Main Underground Works carried out since 31.3.1914.
- S. Map showing extension of Telegraph Underground routes since 31.3.1914.
- T. Map showing extension of Telephone Underground routes since 31.3.1914.
- U. Schedule of Main Underground Works included in the 1919-20 Trunk Telephone Programme.
- V. Summary of work done in connection with the development of Local Telephone Systems since 31.3.1914.
- W. Lists of New Manual C.B. Exchanges opened and of important extensions to Manual C.B. Exchanges carried out during War period.
- X. Schedule showing Power, Lighting, Heating, etc. services as at 31.3.1917.
- Y. Summary of wire mileages of Post Office Telegraph and Telephone systems as at 31.3.1914 and 31.3.1919.
- Z. Some particulars of new apparatus designs produced during war period for departmental purposes.
- AA. Schedule showing value of orders for Telegraph and Telephone apparatus (excluding military) placed since 31.3.1914.
- BB. Statement showing value and quantity of cable, wire, apparatus, etc. inspected and reported on since 31.3.1914.
- CC. Map showing principal Submarine Cables provided during War period.

The Secretary,

In accordance with the Secretary's minute of 1st instant, I beg to submit the following report on the work carried out by the Engineering Department during the years 1914-1919, a large proportion of which was in connection with the provision of services, stores, and men for War purposes. The report has been prepared under two main headings, viz: A. Engineering work carried out in connection with the war, and B. Engineering work, not directly connected with the war, carried out during the war period.

A. ENGINEERING WORK CARRIED OUT IN CONNECTION WITH THE WAR.

CUTTING OF  
GERMAN CABLES.  
(August 1914)

SUBMARINE CABLES.

1. On the night, August 4th 1914, that War was declared, the Department's Cable Ship "Alert", commanded by Mr. J. Bourdeaux, stood under steam awaiting orders to undertake a special duty. Her immediate orders were on receipt of a pre-arranged message, to apply to the local Admiralty Officials for an escort and then to proceed to sea, with sealed orders as to the special work to be undertaken. The message was received and application was made to the King's Harbour Master for the escort, but the reply was that all Naval vessels had left and that the "Alert" would have to wait until a suitable vessel was available. Mr. Bourdeaux pointed out that his orders were emphatic and that he must go to sea at once, and added that if no escort were available he would have to go without one. After some discussion permission to leave was given, although the Harbour Master said he would not hold himself responsible for the consequence and that Mr. Bourdeaux would have to take the full responsibility himself. This Mr. Bourdeaux promptly acknowledged and having already seen that his cable tools were in first class condition to undertake any work

work that his orders might require, he put to sea without escort or protection of any kind. The instructions on being opened were found to require the cutting of the five German Cables passing down the Channel from Borkum to Brest, Vigo, Teneriffe and Payal (2) respectively.

The operations were promptly and successfully completed in the early morning of the 5th. No hostile craft was encountered, but a French war vessel appeared on the scene during the process of cutting one of the cables. She flew no flag and gave no indication of her nationality, but challenged the "Alert", demanding her name and business. The answer was of course satisfactory, but at the time no one on board knew whether the challenge came from friend or foe and very great credit is due to everyone on board for the ready and willing compliance with orders and for undertaking such great risks without any possible hope of salvation in the event of a hostile vessel coming up with them while they were at work. The operations are set out in greater detail in the papers which contain the special report of Mr. Bourdeaux.

The cables connecting England and Germany were disconnected on this side on the evening of the 4th and before War was declared, but on receipt of remonstrances from Germany, communication was temporarily restored. It was of course broken again as soon as War was declared, and on the following day the Anglo-German cables were all cut below low water mark, in order to prevent any accidental re-establishment of communication, or the illicit use of the cables by enemy agents. For many months after the outbreak of War, there were frequent reports of cable communication having been set up and it was even asserted by the Admiralty that one of the German Cables cut by the "Alert" was working, although as a matter

matter of fact a portion of the cable in question was lying on my table so that it was a physical impossibility for the cable to be in use. Many journeys were made to the East Anglian coast with the object of ascertaining by induction and other means whether any single wire cable was working, but nothing whatever could be traced, although the movements of certain individuals in the neighbourhood of the Norfolk Coast gave warrant for a certain amount of suspicion. The difficulties attending our operations in this matter were considerably increased by the Naval regulations concerning the movements of Mercantile Craft, as many of our cables were interfered with by ships' anchors and dragged for considerable distances away from their normal positions.

CABLE SYSTEM  
FOR GRAND  
FLEET AT  
ORKNEY, ETC.

2. The Department's Cable Ship "Monarch" left the Thames at Midnight on 4th August 1914 for the Firth of Forth to take charge of the submarine cabling operations to meet the requirements of the Admiralty. The assembly of the Grand Fleet at Scapa Flow assumed such importance however, that in December 1914 it was arranged that the "Monarch" should be based in the Orkneys to act as Cable Ship in attendance upon the Fleet and was placed at the disposal of the Admiral in Command. Most of her work was of secret nature, and her Commander took his instructions direct from the Admiral and only looked to this Office to keep her supplied with an adequate stock of cables of various types and sizes, and to maintain her personnel. I am happy to be able to report that the Admiral spoke very highly of the efficient manner in which the main and local telegraph and telephone systems were maintained.

The early months of the War were however exceptionally  
busy



busy ones, and very heavy demands for cable work round the coasts and particularly in the English Channel were poured in upon the Department. It therefore became imperative to increase the number of Cable Ships at our disposal and early in 1915, it was seen that it would be necessary to withdraw the "Monarch" and replace her by another vessel which, while somewhat less well equipped than the "Monarch", would be quite suitable for the work in hand by the latter. Accordingly arrangements were made to take over from the Admiralty the Lancashire and Yorkshire Steamship "Hodder", and to equip her as a Cable Ship. This was done and the "Hodder" relieved the "Monarch" in May 1915. The "Hodder" remained with the Grand Fleet until March 1916 when owing to heavy demands elsewhere she was withdrawn and her place was taken by the large trawler "St. Hubert" which had been equipped as a Cable repairing vessel. The Admiralty concurred in the arrangement, but the Admiral in Command was not satisfied and in the following July, the Lancashire and Yorkshire Railways Company's Steamship "Mersey", a sister ship to the "Hodder", took her place. The "Mersey" was accordingly taken over in November 1915, was specially fitted out as a Cable Ship by the end of March, and was employed in the cable work of the Department up to the time of her transfer to Scapa Flow in July 1916.

1915  
see below

The cable system in the Orkneys comprised at the time of the Armistice 115 separate cables, the maintenance of which provided full occupation for the Cable Ship.

The concentration of a Naval force in the Forth necessitated the stationing of a small cable vessel

in

in these waters and the steamer "Madis" which was loaned to the Department by the Admiralty was specially fitted out for Cable work and commissioned for the work in July 1917.

In order to meet Admiralty requirements it was necessary during 1915 to provide cable connection with the Tongue, Edinburgh, Galleper, Sunk, Longsana, and Shambles Lightships. The maintenance of the Lightship cables has been an important feature of the work of the cable ships.

The number of small works in the estuary of the Thames became so great and pressing that arrangements had to be made to provide a small vessel for these works and the steamer "Edward VII" was suitably equipped in November 1917 and placed at the disposal of the Admiral at the Nore.

Appendix A which gives details, including the approximate cost, of the principal cables laid or provided since the outbreak of War, also includes some particulars of the cables provided for the Admiralty in the Orkneys, the Firth of Forth, and elsewhere in the British Isles. A map marked Appendix .CC . shewing the principal cables, is also herewith.

**EMERGENCY CABLE  
DEPOT AT  
PLYMOUTH.**

3. From the very commencement of hostilities it was evident that considerable risks were incurred in bringing out Cable Ships into the Thames and the Admiralty pressed for the provision of a Cable Depot somewhere near the mouth of the English Channel. I made special visits to Plymouth and other places, and in company with Admiral Egerton inspected all the waterways and possible premises in the neighbourhood of Plymouth. Ultimately I selected a small wharf

adjacent

adjacent to the Victoria Wharf, which contained three large rectangular tanks which had up to some 20 years or so previously been used for sewage purposes but which had since been filled in with earth &c.

Arrangements were made for hiring this Wharf and the tanks were cleared with a view to using them as Cable tanks. They served the purpose fairly well although it was found impossible to make them quite watertight except at a prohibitive cost. The tanks were brought into service in 1915 and have since been continuously used for storing new cable upon which Cable Ships could draw, and for storing recovered cable. While this Depot has been of great service during the War, it is not altogether an ideal one for peace conditions and the location is not quite suitable.

4. (1) The Eastern Telegraph Company's Cable Ship "John Pender" was chartered in September 1914 and her first task was to pick up 247 nauts of the Borkum-Fayal 1903 cable, between Folkestone and Land's End. She also recovered 60 nauts of the Borkum-Teneriffe Cable to the West of Cherbourg and led the eastern section of the Cable into Cherbourg and Dunkerque to form a Dunkerque-Cherbourg circuit for the French Administration. She also led the Borkum-Brest cable into Cherbourg to form a Cherbourg-Brest circuit for the French Administration, using 47 nauts of the recovered cable for the purpose. This cable recovered from the Borkum-Fayal 1903 cable was in very good condition and 91 nauts of it were laid in October 1914 as a new direct cable between Dartmouth and Jersey, to supplement the existing

SPECIAL SUBMARINE  
CABLES PROVIDED  
DURING THE WAR.

Dunkerque-Cherbourg  
Cable  
(September 1914)

Cherbourg-Brest  
Cable  
(September 1914)

Dartmouth-Jersey  
Cable  
(October 1914)

existing 3 core cables between Dartmouth and Guernsey and Guernsey and Jersey. The frequent failures of these 3 core cables had been a source of serious embarrassment even in normal times and as events subsequently proved, the new cable was a very valuable reserve.

St. Margarets-  
Dunkerque Cable  
(October 1914)

(ii) The Admiralty being very anxious to establish direct communication between the Admiral at Dover and the Commander at Dunkerque, a length of 39 nauts of the recovered cable was used to give that service and was laid in October 1914 by the "John Pender". Although this is only a single core cable we were able to establish not only a telephone circuit but also a telegraph circuit by its means.

*This cable was laid to give direct communication with the British Forces moving to the right of the Armies in France. We were told Admiralty came later.*

Jersey-St. Malo  
Cable.  
(September 1914)

(iii). In September 1914 the Eastern Telegraph Company's Cable Ship "Electra" was chartered and laid a new cable between Jersey and St. Malo, and this, during a very critical period of the War was joined to the then recently laid Dartmouth-Jersey Cable to complete a London Paris circuit.

Birling Gap-  
St. Nazaire Cable.  
(September 1914)

(iv). The advance of the German Armies towards Paris and the jeopardy in which the Channel ports were placed resulted in the removal of the seat of Government in France from Paris to Bordeaux, and of the British Army Headquarters to Nantes, and this made the provision of telephonic communication between London and St. Nazaire a matter of extreme urgency. I therefore devised a scheme for providing such communication and promised to complete it within 10 days from the receipt of authority to proceed. This was speedily forthcoming and I employed three Cable Ships for the purpose viz: the India Rubber and Gutta

Percha Company's Cable Ship "Dacia", the Telegraph Construction and Maintenance Company's Cable Ship "Telconia" and the Department's Cable Ship "Alert". The "Telconia" with cable on board proceeded to a point off Brest with instructions to pick up the Borkum-Vigo cable cut it and hold the eastern side until the "Dacia" arrived. The "Dacia" having taken on board sufficient cable for her purpose, proceeded down Channel, took the end of the Borkum-Vigo cable from the "Telconia" and then extended it by means of the cable she had on board, to St. Nazaire. In the meantime the "Alert" proceeded to a point off Beachy Head and also picked up the Borkum-Vigo cable with instructions to cut it and hold the western end until the "Telconia" was able to come up from Brest. On her arrival the "Telconia" extended the Vigo cable to Birling Gap where a land line was in readiness to complete the circuit to London. The total length of the cable was 475 nauts of which 233 nauts originally formed part of the Borkum-Vigo cable. It was necessary to employ the "Telconia" to make the extension to Birling Gap as the "Alert" was too small to carry the requisite quantity of cable.

While the cable was being laid one of my officers proceeded overland to St. Nazaire with the necessary apparatus and supervised its installation there, transferring it to Nantes a few weeks later. This Officer is one of the few civilians who have been awarded the 1914 star.

(v). In order to provide direct telegraphic communication with Russia arrangements were made in

Anglo-Russian  
Cable  
(January 1915).

December 1914 for laying a cable between Peterhead and Alexandrovsk, to work in conjunction with land lines between Peterhead and London and between Alexandrovsk and Petrograd. For this special work the Telegraph Construction and Maintenance Company's "Colonia", the largest cable ship in the world, was chartered and loaded with 1512 nauts of cable commandeered by me under Army Council Order from that Company's tanks, and with 96 nauts of the German Fayal 1903 cable recovered from the Channel. The staff to work the cable, consisting of a Superintendent and 9 telegraphists loaned by the Eastern Telegraph Company and 9 telegraphists selected from the Post Office staff together with a Doctor and a cook, were also taken out by the "Colonia", together with a complete equipment for working the cable at Alexandrovsk as well as the land line to Petrograd. She also took out a supply of food sufficient to last for at least three months, furniture for the Office, bedrooms and large sitting room, an equipment of tools, a library, games &c. for recreation purposes, in fact everything essential for the equipment and maintenance of the station and to meet the requirements of the staff, the only provision made locally being the buildings which were all of wood. The stores taken by the "Colonia" were contained in no less than 584 cases. Every case was numbered and a lengthy schedule was provided setting forth the contents of every case.

The vessel left London in December 28th 1914 but owing to the war risks attending a voyage up the east coast to Peterhead she was sent round by way of the west coast of Ireland and the Orkneys and encountered

very

very rough weather on the way so that she was not able to land the shore end at Peterhead until January 8th when she immediately proceeded with the laying of the cable, of which she paid out 1427 nauts and made the final splice off Alexandrovsk on 19th January 1915. She was escorted by one of H.M. Cruisers throughout the operations, in addition to four destroyers who accompanied her from Peterhead to a point which was considered beyond the danger zone.

On the day (28th December 1914) that the "Colonia" left London I started for Peterhead to see that adequate provision was made for the installation of the apparatus at the British end of the cable. The accommodation available in the Post Office was not more than one half of the minimum required for the purpose and there was no accommodation available anywhere else in the town. Fortunately the building adjacent to the Post Office was built on the same general elevation as the Post Office and by taking very strong measures such as could only be made under stress of War, I got the top floor of this building evacuated by the tenants at 24 hours notice, and had workmen ready to knock down the party wall between the two buildings so as to make one large room extending over the two houses. Fortunately, I was able with the very loyal assistance of the Postmaster to get the men to work before the Scottish New Year festivities set in so that they were able to work right through New Year's eve and New Year's Day. Suitable tables were also made and the apparatus being already delivered on the site, the Office was very speedily equipped.

While this was going on a land line was being erected on an existing pole line between Peterhead and Aberdeen (to meet a line which was made available between Aberdeen and London) and the streets of

Peterhead

Peterhead were being trenched and an underground cable was being laid between the Post Office and the existing cable hut on the shore. A staff of electricians had been provided by the Telegraph Construction and Maintenance Company for the purpose of keeping the cable under test during the laying operations and to keep in touch with the "Colonia" so that I was able to know every day how the work was proceeding.

A very efficient officer had been lent by the Eastern Telegraph Company to act as Superintendent at Peterhead and he supervised the equipment of the instrument room so that by the time the final splice was made at Alexandrovsk he was able to make and complete his "balance" and be ready for duplex working as soon as possible after the Alexandrovsk staff had got the cable extended to the Office, unpacked the apparatus, got it into position and joined it up. I returned to London after making all the arrangements set forth above, but went back to Peterhead when the "Colonia" had completed her work, in order to see that no time was lost in bringing the cable into service. On the 24th January the cable was handed over by the Contractors, and after the passage of congratulatory messages, the circuit opened for simplex working on the 28th - that is to say within one month from the day on which the "Colonia" left London. The Alexandrovsk staff were anxious to continue simplex working and to defer any attempt at duplex until the accumulation of traffic had been cleared off. It was however obvious to me that such an opportunity would not present itself in the near future, and I accordingly decided that it would be better to suffer a little longer delay and make a serious attempt to get a duplex balance and make a fair start at duplex. Accordingly traffic was suspended and with such assistance as could be given from this end, Alexandrovsk was able to obtain a satisfactory balance and



at 7 p.m. on January 31st the circuit was reopened and worked under duplex conditions at a speed of 140 letters per minute in each direction. Since then it has worked exceedingly well; and only one fault in the cable has occurred (in November 1918) apart from interruptions due to earth currents.

Circumstances have fully justified my contention that Peterhead was the best landing point and that the route which I mapped out for the cable was the most reliable. The Admiralty was anxious that the cable should be landed at Lerwick, but there were no suitable connections between Lerwick and Aberdeen and it would have taken months to provide them; there was no cable hut available between Lerwick and Peterhead and it would have been impossible to keep the cable under observation during laying. The cable has been of inestimable value during the War, and it is a source of considerable gratification that when all the accounts had been rendered and all claims paid my estimate of £250,000 showed a very small surplus of some £8,000.

On 28th September 1916 the office at Alexandrovsk was destroyed by fire and the work of re-equipping it devolved upon me. Sufficient apparatus was saved to enable the cable to be re-opened on October 1st and worked simplex until new duplex equipment had been got together in this country and shipped to Russia. This equipment was sent out before the end of October and duplex working was re-established on 26th November. A duplicate equipment was supplied to the Russian Government in March 1917 and is housed in a separate building at Alexandrovsk. This apparatus, etc., which filled 299 cases and weighed altogether over 23 tons, cost, together with the equipment sent out in

Duplicate  
equipment at  
Alexandrovsk,  
(October 1916-  
March 1917).

October, £4,762.

Duplicate  
equipment at  
Peterhead.  
(August 1917)

At the request of the Military Authorities a duplicate office and equipment were provided at Peterhead in August 1917, at a cost of £1963, as a stand-by in case of the destruction of the Peterhead Post Office by enemy action.

Additional  
cables in  
the White  
Sea  
(August 1917)

(vi) The general success which attended the working of the Peterhead Alexandrovsk, and the inadequacy of the land lines in Russia to carry the traffic, particularly to Archangel led the Russian Government to propose an extension of the cable from Alexandrovsk to Archangel. This proposal however was one which I could not support owing to the serious reduction in speed which would have resulted. A proposal to lay a new cable from Peterhead was also considered but was ruled out on the ground of expense, and of the comparatively small amount of traffic for Archangel. It would have been possible to increase the speed of working on the Peterhead-Alexandrovsk Cable to the extent of about 30 per cent by using Heurtley Magnifiers and steps were taken to instal the necessary equipment. The need for cable communication to Archangel still remained and I designed a cable to be laid between Alexandrovsk and Archangel with a loop into Yukanski, where it was proposed to insert a repeater. The calculated capacity of this cable was 60 words per minute duplex using ordinary Wheatstone apparatus. The matter was very fully considered in all its bearings, commercial and strategic, and following a decision made by the War Cabinet, Messrs. Siemens Brothers Cable Ship "Faraday" was despatched to the White Sea in June 1917 with one of my Engineers in charge of the operations to lay the cables necessary to link up the Russian northern ports but as the operations of the enemy were becoming more  
daring

daring and pronounced it was decided to make Murmansk the key to the situation. Consequently a new single core cable was laid under the supervision of one of my Cable Engineers between Alexandrovsk and Murmansk, Murmansk and Yukanski, Yukanski and Archangel, another of my Engineers arranged the equipment of offices at Murmansk, Yukanski and Archangel with apparatus etc. which had been manufactured under my direction and taken out at the request of the Russian Administration. The charges for apparatus in connection with the scheme amounted to 92,364. One of my Mechanics accompanied the expedition and gave the Russian staff instruction in the maintenance of the apparatus. (This man unfortunately lost his life through the torpedoing of the ship on which he was returning to England). Provision was made as indicated above for working the cables on the Wheatstone duplex system so that Murmansk and Archangel could work together directly, or either of them separately with Yukanski. The Murmansk-Yukanski cable was opened for traffic on 12th August 1917 and the Yukanski-Archangel cable on the 24th August 1917. A new four core coil-loaded telephone cable was also laid between Intzi and Pyalitzka; and a duplicate length of this cable was deposited in Archangel for subsequent use; and two telephone cables were laid across the Northern Dwina at Archangel. The cable used during the expedition amounted to 598 nauts. Considerable difficulties were encountered owing to climatic conditions and to the extraordinary apathy of the Russian officials. The work was carried out with practically no native assistance. The "Faraday"

reached

reached the Thames safely with a load of timber on 11th November 1917.

Repair of  
faults in  
Kola Inlet  
(Summer 1918).

Faults were reported in April 1918 to have occurred on the Alexandrovsk-Murmansk and the Murmansk-Archangel cables in the Kola Inlet. An attempt by one of my Cable Engineers, who was sent out specially to clear the trouble with the aid of local craft, having proved unsuccessful, the Cable Ship "Monarch" was commissioned in June to carry out the work. In consequence of the Bolshevik threat to the Murman coast suitable cable etc., and expert staff were sent on the "Monarch", so that, should the necessity arise, apparatus could be transferred from Alexandrovsk to Archangel and the Peterhead-Alexandrovsk cable joined to the Murmansk-Archangel connection, cutting out the Kola Inlet loop, to form a slow-working direct Peterhead-Archangel circuit. On the arrival of the ship at Murmansk however the Naval and Military Authorities had decided that the diversion should not be made. The cable repairs were therefore proceeded with and completed by the 30th June and the vessel reached Woolwich again on the 25th July, 1918.

I am glad to be able to say that considerable assistance has been given by the Ministry of Shipping in facilitating the despatch of stores to Alexandrovsk and Archangel on several occasions.

Dungeness-  
Audrecelles  
No.1 Cable.  
(January 1916)

(vii) The Anglo-French communications have been a source of considerable trouble and anxiety. Most of the cables cross the Straits of Dover in a very restricted area, and, owing to the many breakages due to vessels anchoring and to the operations of mine sweepers, there was at one time a serious possibility of communication being totally interrupted in this area,

and

and I made special investigations with a view to opening up a new cable route. The result was quite satisfactory and in January 1913 a new 6-wire telegraph cable was laid between Dungeness and Audrecelles, a route outside the danger zone. The arrangements on this occasion included the special manufacture of 10 nauts of cable (to do which, the staff of the Telegraph Construction and Maintenance Company had to work through the Christmas holidays); the sending of the "Telconia" from Dover to the Thames to take on board this cable and 30 nauts of other similar cable from stock; the selection of a landing place at Dungeness; the utilisation of a Lifeboat House there as a cable hut; the erection of 3 miles of new poles across shingle from the hut to Lydd and of 100 miles of wire from the hut to Sandling Junction where existing lines to London were made available; the landing of the shore end with the help of 200 soldiers; the laying of the cable across the Channel by night and the landing on the French side. The work was very urgent and close personal attention was given, which resulted in the provision of six circuits between London and Boulogne, the whole being completed within three weeks from the receipt of authority. The closest cooperation of all parties was essential to permit such a measure of success, and in order to secure this I called a meeting at Folkestone on New Year's eve and assigned to each superior officer his particular part in the programme including the making of the necessary arrangements with the British and French Military Authorities and with the Lifeboat Institution. As it was the work was not done without risk. On

arrival

arrival off the French Coast in the early morning, the attention of the Soldiery could not be obtained as the men were at breakfast. A rocket was therefore sent ashore and fell in the midst of the men who thinking they were in for a bombardment made themselves scarce. Seeing that nothing further ensued they gradually came into the open and soon got to work. The shore end was landed and secured but darkness was setting in when the vessel was ready to start the laying of the cable to the British Coast. The Skipper was anxious to wait until the morning, but my Engineer acted on the spirit of his instructions and insisted that a start should be made. Shortly after they got away a wireless message was received reporting an enemy submarine in the vicinity. At the request of my Engineer all lights were extinguished with the exception of a small light over the compass and he undertook to give the Captain his directions for navigating purposes. As a result the cable was successfully laid and in such a true course that only one-third of a naut of cable was laid in excess of the true straight line length.

Dover-  
Dunkerque  
Cable.  
(January 1917)

(viii) In view of the importance of the operations of the Dover Patrol, the Admiralty desired early in January 1917 to secure additional telephonic communication between Dover and Dunkerque. Forty-two miles of the four core coil-loaded cable provided immediately before the War for the Anglo-Dutch telephonic service were used, and as the cable was more than an ordinary cable ship could carry, two vessels were employed, one half of the cable being laid by the "Teleonia" from Dover and the other half by the "Mersey" from Dunkerque. The risks were very great and the two vessels left the Thames together under secret orders, and kept together until they reached Dover. In order to avoid all risk of tapping or overhearing I visited Dover beforehand and arranged a new cable landing place at Dover

with

with an underground connection to the Admiral's Office. In spite of adverse weather conditions the operations were carried out expeditiously and the cable, which was brought into use on the 25th January, has given excellent service.

(ix) Another section of the Anglo-Dutch cable was utilised in August 1917 for a new telephone cable between Dover and Sangatte in connection with the service for the Royal Flying Corps.

Dover-Sangatte Cable. (August 1917)

(x) Owing to the heavy expenditure involved in the frequent repairs to the Beachy Head - Havre Telegraph Cable and the great traffic pressure on the Anglo-French cables I came to the conclusion that it was inexpedient to make any further repairs and recommended its renewal by a new cable. Seventy nauts of 4 core cable were accordingly manufactured and laid between Cuckmere and Havre in one operation by the Eastern Telegraph Company's Cable Ship "John Pender" early in September 1917. This work involved a visit to Cuckmere the selection of a new landing place and the provision of a cable hut or its equivalent. The Western Union Telegraph Company has a hut of a fairly good type and only one single core cable led in. I tried to make terms with the Company to lead our cable in but the rent asked was to my mind exorbitant and I therefore made arrangements to use the Coast Guard Station.

Cuckmere-Havre No. 1 Cable (September 1917)

(xi) In connection with the entrance of the United States of America into the War and the system of communications placed at their disposal in this country, it was necessary, in order to provide adequately for

Cuckmore-Havre No. 2 Cable. (February 1918).

America's

America's telegraphic traffic, to lay a new four-core cable to France. The necessary seventy nauts of cable were manufactured quickly to my orders and were laid by the "John Pender" between Cuckmore and Havre during the evening and night of 17th February 1918. To connect the cable with London four wires were provided, two of which had to be created for the greater part of the distance. In London connections were given between the U.S.A.H.Q., the Western Union Telegraph Company's Office and the C.T.O. One morse duplex repeater and two Baudot repeaters were provided for use at Havre and 4 sets of double current sounders apparatus were sent to Paris. The service from London was proved as far as Havre and handed over to the American Army Authorities on the 25th February 1918.

Dungeness-  
Audrecolles  
Nos. 2 and 3  
cables.  
(May 1918).

(xii) To meet the requirements of the Military Departments and of the United States of America for direct telephonic communication with France, arrangements were made for laying two additional cables between Dungeness and Audrecolles during the Spring of 1918. Thirty nauts of four core coil-loaded cable were specially manufactured and 22 nauts of the Anglo-Dutch cable were appropriated for the work. The "John Pender", commencing from the English side, first laid the Number 2 cable, and then the Number 3 on the return journey from Audrecolles. It was necessary to erect 30 miles of the pole line between Dungeness and Ashford in connection with the scheme and the new route was brought into use on the 28th May 1918.

During my visit to France in March 1918 (see Section 99) I proposed a rearrangement of the Anglo-French Telephone Cable circuits with a view to allocating the better routes to the longer circuits and the older and inferior routes to the shorter circuits, and in co-  
operation



operation with the French Administration, the scheme was carried into effect in the following month. The completion of the Audrecoches cables also enabled advantageous changes of a similar nature to be made.

(xiii) The possibility of the German forces severing the Anglo-French lines of communication via Calais and Boulogne in the Spring of 1918 suggested the desirability of making preparation for the provision of such communication by a more westerly route. Accordingly a scheme was framed for providing, if necessary, two four-core telephone cables and one seven-core telegraph cable between Cuckmere and Antifer, and I made arrangements for the manufacture of the necessary 240 nauts of cable and for the construction of a new pipe line connecting the London and Brighton underground cable with Cuckmere. In view however of the change in the military situation the scheme was not proceeded with; the 120 nauts of telephone cable manufactured to date were placed in reserve; the order for the remaining 40 nauts was cancelled; the manufacture of the 80 nauts of telegraph cable was completed but not laid; and it was arranged for the underground cable from Brighton to be terminated at Eastbourne instead of Cuckmere. The submarine cable will cost the Department approximately £190,000 and the underground work £27,000. Twenty nauts of the telephone cable have already been used for the Dover-Sangatte No. 2 cable, next referred to.

Anglo-French  
Emergency Cable  
(1918).

(xiv) In view of the Peace Conference, arrangements were carried out, in cooperation with the Director of Army Signals, France, to provide six additional

Dover-Sangatte  
No. 2 Cable  
(November 1918)

telephone

telephone circuits to supplement the London-Paris service. Spare cable accommodation existed for three of those circuits but for the other three it was necessary to lay an additional cable between Dover and Sangatte. Twenty nests of four-core coil-loaded cable, which had been manufactured for the emergency purposes, above referred to, were accordingly laid by the "Monarch" on the 29th November 1918. The six English land lines were made available in the London-Dover underground, and rendered highly efficient by means of telephone repeaters placed in circuit at Dover.

The circuits however have not worked nearly so well as could have been wished. There have been many interruptions in the French land lines and it has rarely happened that all six circuits have been simultaneously available for traffic.

ATLANTIC  
CABLES SCHEME  
(December 1918  
onwards)

5. A very considerable amount of work fell upon this Department in connection with the appropriation of the two German Cables from Borkum to New York via Fayal. It is unfortunate, in the light of War experience, that the proposal of the German Administration that the cables should be landed in England was not agreed to. Had it been agreed, we could have brought the cables into use in the early days of the War and with much less trouble than was actually experienced. I think that in this matter, the British Government played unduly into the hands of the American Cable Companies.

The scheme in view when the question of appropriation was first considered was that the two cables should be diverted into England in the neighbourhood of Lands End, and into Halifax N.S. instead of New York. I made a very minute inspection of the Cornish Coast line and found that the most favoured proposal, viz. to land the Cables at

Porthcurno

Porthcurno, was impracticable owing to the congested condition of that landing point. Ultimately I decided upon making the landing at Mouscholo, a small hamlet near Penzance. The next difficulty was to provide quickly a suitable Cable Hut. I tried to get possession of a cottage or other building, but all were in occupation, and if we had evicted any of the occupiers there would have been nowhere else wherein to house them. As the result of prolonged enquiry and search I came across a box or tank which had been designed for a oilchard tank but which had never been used for any purpose. It measured about 11 feet square and the bottom and four sides were of solid concrete; but there was no roof. Arrangements were made to rent this, a roof was put in and a door made in one of the sides, resulting in the provision of a very serviceable cable hut, particularly as it is situated near the water side and in proximity to the cable landing point. It was determined to locate the Repeater Station at Penzance, but as the Post Office could not provide the necessary accommodation new premises had to be acquired. I came across a Social Club which was in rather low water, and made the necessary arrangements to commandeer it and adapt it for our purpose. It has answered exceedingly well, and there is sufficient ground in the vicinity, all the property of one and the same landlord, to provide adequate accommodation for a much-needed new telephone exchange and engineering depot. A new underground route had to be surveyed and the necessary wayleaves obtained at very short notice, in order to connect the repeater station with the cable hut at Mouscholo. Upwards of 100 men were drafted into the town for the trenching and cable laying and considerable difficulty was experienced in providing the trench owing to the

peculiar formation and extreme hardness of the rocks through which the trench had to be made. In several places the only method by which the rocks could be moved was to dig holes under them and split them by building fierce fires in the holes. The work was however completed very effectively and expeditiously and a cable was laid which could have provided extensions for the two submarine cables had they both been diverted. It was subsequently decided however, that only one of the German Cables should be diverted into England, the other being placed at the disposal of the French Administration.

Arrangements were also made with the Canadian Government, the Pacific Cable Board, and the Halifax and Bermuda Cable Company for the landing of the diverted cable near Halifax, the erection of a Cable Hut for joint occupation by the Government and by the Halifax and Bermuda Cable Company, and for a joint underground cable extension to the two Cable Offices, for which accommodation was provided in the same building. The Cable Hut was built to my specification and the necessary lengths of underground cable for the extension were sent from this country. The iron pipes in which the cable was laid were provided locally, the Railway Engineer of the Canadian Government acting as my local representative and working to my instructions. The laying of the cable was supervised by one of my telegraph engineers with the assistance of an experienced underground cable joiner. The Engineer also installed the apparatus at Halifax and remained in charge of the equipment for several months. That equipment (including the underground cable) which filled 350 cases and weighed when packed 28 $\frac{1}{2}$  tons, was also manufactured here to my order and was taken out

by

by the Telegraph Construction and Maintenance Company's Cable Ship "Colonia" which carried out the diversion operations in the Atlantic.

It was of course a big task to get together the necessary submarine cable for making the projected diversions, but it was with great satisfaction that I was able to load up the "Colonia" which I had chartered for the work with 666 nauts of cable, including the following lengths of new and specially manufactured cable:-

6 nauts	twin core	600/340	15/0
14 "	" " "	"	15/1
80 "	single "	"	10/2
170 "	" " "	"	12/3
200 "	" " "	"	10/13
77 "	" " "	"	18/14

and the following lengths of commandeered cable

149 nauts	single core	650/375	19/14
170 "	" " "	500/320	17/12 $\frac{1}{2}$

The "Colonia" sailed from the Thames on 25th November 1916 having on board Mr. J. Bourdeaux as my representative to superintend the cabling operations and the engineer and joiner above referred to. Under Admiralty instructions she put into Plymouth and was detained there until 21 February 1917 when she left under the escort of a French Cruiser. As it happened this enforced detention was most unfortunate as the weather which for the great part of the time had been exceptionally favourable for the work in hand, became very bad indeed and resulted in considerable delay and in even a greater proportional cost. Prior to the sailing of the "Colonia" it had been decided that the French Administration was to have the use of

one of the cables, and accordingly the instructions were to divert the Fayal-New York 1904 Cable into Halifax and the Fayal-New York <sup>1900</sup> Cable into St. Pierre. The work was particularly arduous and difficult. The depth of water in which the cables were laid was over 3000 fathoms and the sea bed upon which the cables were resting consisted for a considerable distance of volcanic matter, so that grapnels were damaged and the cables were either not capable of being picked up, or if picked up broke upon the rough bottom. Consequently considerable lengths of new cable had to be laid to bridge over the numerous breakages. Further the submarine danger and the very stormy weather encountered seriously delayed the work. On one occasion the ship on entering Halifax was covered with ice a foot or more thick (vide photograph No. 2 in Appendix B) and as the circulating water for heating the cabins etc. was frozen the officers and crew suffered considerable hardship. Before the scheme was completed the United States of America came into the War and orders were received for the cable which was to be used by the French to be put through to New York instead of St. Pierre. The diversion to Halifax was satisfactorily completed and the cable to New York put into good condition up to a point quite close to New York. The repair of the section leading in to New York was undertaken by a French cable ship. In all, 713 nauts of cable, which cost £205,250, were used in the "Colonia's" operations and the vessel, after dry docking at Montreal, arrived at Bristol, on October 10th 1917, with a cargo of wheat and flour and the residue of the cable she took out.

While these works were in progress, the Eastern Telegraph Company's Cable Ship "Sentinel" repaired the breakages at points a few miles west of Fayal where the cables had been cut in the early days of the War at the instigation of the Admiralty.

The Cable Ship "Monarch" had been set the task of diverting the Borkum-Fayal 1903 cable into the Mousehole cable hut but when she had laid the shore end the submarine danger became so great that she had to be withdrawn. Ultimately the Admiralty pressed for the Fayal 1900 cable to be used owing to the fact that it passed nearer to the British Coast than did the 1903 cable. Under the circumstances the proposal was agreed to and the work of connecting up the shore end to the main cable was successfully undertaken by the "John Pender".

The circuit was extended to London by means of a conductor in the Western Underground Cable.

The Penzance-Fayal section of the cable was brought into use on the 7th March 1917 but it was not possible to hand over the whole of the Imperial cable for traffic until the 16th July, 1917. Its great length, viz: 4246 miles, coupled with the fact that there are two repeaters in circuit, viz: at Penzance and Fayal, make the London-Halifax circuit a difficult one, but the service given by the cable during the succeeding months was highly satisfactory. The output frequently amounted to over 30,000 words a day. A fault however occurred on the cable, about 1125 nauts to the East of Fayal, and faults were caused in the Borkum-Fayal 1903 cable and in the Eastern Telegraph Company's Porthcurno-Madeira cable in the same locality and in the same way, on December 15th 1917. In consequence of the submarine difficulty the work of repair could not be taken in hand for a long time. The Western Union Company's Cable Ship "Kinia" was ultimately brought across the Atlantic to carry out the repair and started on the Eastern Telegraph Company's Cable. She did not complete this repair although she made considerable efforts,

efforts, but circumstances were against her and eventually she was withdrawn and the "John Pender" took up the repair of the Porthurno-Madeira Cable. She encountered considerable difficulties and on the 14th January 1919 the "Colonia" was rechartered for the repair of the Fayal Cable. She restored the Penzance-Fayal Cable on 4th February 1919. The circuit is now again working quite satisfactorily and the traffic output mentioned above is frequently realised.

The Borkum-Fayal 1903 cable should have been handed over to the French Administration, but, owing to hesitation on the part of the French as to the point at which it should be landed and the means to be adopted for landing, the work could not be carried out before the unrestricted submarine warfare set in. I suggested in the early days of the negotiations that the cable should be led into Cherbourg as the Fayal 1900 was much nearer to that point than to any other part of the French Coast. The French Administration demurred, although later on, when too late, (owing to the prior use which had been made of the cable) they asked for this to be done. The French pressed for the cable to be led into Brest, but were somewhat perturbed owing to the length of cable that would be involved, and I suggested that the cheapest and most satisfactory method would be to join the Fayal 1903 cable to the Western side of the Cherbourg-Brest cable. It was understood that little or no use was being made of the latter cable and my suggestion, which seemed to be a good solution, was eventually adopted. Another proposal in which however I failed to see much advantage was to lead the cable into Penzance and take it back to Brest by means of the existing French Company's Penzance-Brignogan Cable, but this suggestion was not concurred in. The agreement to make the Brest connection in the manner above referred



to was arrived at at a time when the Admiralty could not see its way to consenting to a British Cable Ship working in the locality, neither would the French Administration risk its new Cable Ship, but the Admiralty ultimately agreed to the "Sialkot" a converted trawler undertaking the work of connecting the Fayal cable with the Western portion of the Cherbourg-Brest to form a Brest-Fayal circuit. This operation was completed in July 1918. The fault further West, in the same area as that which occurred on the Imperial cable (late Borkum-Fayal 1900 cable) in December 1917, was repaired by the "Colonia" on the 28th February 1919, thus completing the Brest-Fayal-New York service for the French Administration.

The total cost of the work in connection with the Atlantic Cables Scheme (excluding cost of the 1919 repairs to the Imperial and Brest-Fayal Cables and allowing credits of £11,450 in respect of freight brought from Canada and of £57,991 in respect of cable not required and brought back) was £374,101, of which it is estimated £137,941 will be borne by the French Administration.

A few photographs showing various operations in cable work on the "Colonia", which may be of interest, are also given in Appendix B.

\* Furnished to Secretary only.

6. Early in November 1918, in accordance with arrangements made with the Admiralty, I arranged for the recovery of the length of the Borkum-Fayal 1900 cable which was lying unused in the English Channel between points off Beachy Head and the Lizard. The "Hodder" left Dover on the 11th November to commence operations from the eastern end, and in two trips recovered 127 nauts of cable which were discharged  
into

RECOVERY OF  
GERMAN CABLE IN  
CHANNEL.  
(November 1918)

into the Department's tanks at Plymouth. The "Hoharch" which had to come from the west coast of Scotland commenced the work of recovery from the western end on the 15th November, picked up 58 hauls of cable and discharged them at Woolwich. The cable was generally in very good condition.

Particulars of the German cable picked up and used in situ during the War are given in Appendices C and D respectively.

#### CABLE REPAIRS.

7. As indicated in Section 7. War conditions have caused an increase in the number of interruptions to the cable system and it is interesting to note that from the commencement of the War until January 31st 1919 no less than 285 repairs to submarine cables have been carried out by Cable Ships, 70 of which were in connection with Lightship cables.

In 1917 conditions in the North Sea rendered unsafe the employment of the Great Northern Telegraph Company's Cable Ship for the repair of the Anglo-Norwegian Cables between Howbiggin and Sondervig and Peterhead and Egersund. Consequently one of my most experienced Cable Engineers in the face of much danger first tackled the fault in the former cable with an Admiralty trawler, and succeeded after considerable difficulty in effecting the repair. He subsequently attempted the repair of the Peterhead - Egersund cable with another trawler but unfortunately, owing to persistent bad weather and heavy seas and to the bad condition of the cable, he was unable to complete the repair. The "Lorsey" has since spent some time repairing this cable but further faults on the Norwegian side were left to be dealt with by a Norwegian ship. The cable was ultimately restored to working conditions on 2nd April

1919, but the cable is in very bad condition and is of an inferior type. Its renewal at no very distant date will I fear be necessary.

8. In many cases where new War communication cables or repairs to existing cables in Harbours and other waterways have been required the work has been carried out, independently of Cable Ships, by Working Parties provided in some cases by the Submarine Superintendent and in others by the Superintending Engineers.

WORKING PARTIES.

9. At the request of the Admiralty I have co-operated with the Director of the Anti-Submarine Department in several important submarine cable schemes. In December 1917 that Department desired a number of cable loops to be laid urgently at the eastern end of the Channel, and I made arrangements for providing the necessary cable ship, cable, and expert cable staff. The "John Pender" was available, and after being loaded with over a hundred miles of commandeered cable proceeded with the work under the superintendence of one of my Cable Engineers. A second officer and several jointers etc. were also spared from my staff. In March 1918 the "Hodder" relieved the "John Pender" and until the cessation of hostilities last November carried out valuable work for the Anti-Submarine Department. In April 1918 at the request of the Admiralty, I arranged for the appropriation of a further 135 nauts of cable from the stock of one of the Cable Companies and issued the necessary replacement orders.

CABLE WORK FOR  
ANTI-SUBMARINE  
DEPARTMENT OF  
ADMIRALTY.  
(December 1917-  
November 1918)

Cables for experimental work were laid in the

Clyde

Clyde by the "Monarch" in December 1917, which vessel in March 1918 also laid a cable across the North Channel, between Antrim and Kintyre, for Anti-Submarine purposes.

In addition I have frequently given advice and facilities to Admiralty Officers concerning routes and landing points for hydrophone cables.

At the urgent request of the Director of the Anti-Submarine Department I loaned 20 experienced fitters to the Western Electric Company for several months in 1918 to assist in the fitting up of hydrophones.

DANGERS  
CONNECTED WITH  
THE WORK.

10. The submarine cable work has, throughout the war, been carried out under exceptional difficulties owing to the presence of mines and the menace of enemy submarines which have considerably hampered and delayed ship movements and operations. The Admiralty have consistently provided escorts for the cable ships whilst at sea, and I am pleased to state that although the cable ships when at work form excellent targets, none of them has suffered attack from enemy submarine.

Loss of  
"Monarch"  
(September  
1915).

The "Monarch" however struck a mine off Folkestone on the 8th September, 1915, whilst proceeding to repair the Beachy Head-Havre Cable, and sank almost immediately, with unfortunately the loss of three lives. The estimated value of the hull at the date of loss was £35,000 while the value of the cable and stores lost was £17,700. Unsuccessful efforts were subsequently made by a diver to recover the cable from the wreck. A lifeboat was however recovered and brought into use again, the value of which more than met the expenses of the diving operations. The "Monarch" was replaced in September 1916

by

by the new "Monarch" which was built by Messrs. Swan Hunter and Wigham Richardson at a cost of £85,000.

Very many mines have been exploded in close proximity to the Cable Ships, and on one occasion a submerged mine was raised to the bow of the "Morsey" by the cable grapple. The lowering of the mine was a task of some difficulty and risk but the Officer-in-Charge, Mr. H.F. Bourdeaux, sent the crew aft, directed the vessel to steam backwards and gradually dropped the mine, fortunately without mishap.

Whilst the "Morsey" was engaged on the repair of the Beachy Head - Dioppe cable on the 18th March 1918, a submarine mine exploded on the cable immediately in front of the bow of the ship. Fortunately the damage done to the ship was not serious.

Accident to  
"Morsey".  
(March 1918).

I am proud to say that notwithstanding the dangerous character of their work the Submarine Cable Staff have carried out their duties with remarkable courage, skill, and loyalty.

11. It will have been gathered that the exceptional amount of submarine work undertaken during the War has necessitated the employment of quite a small fleet of vessels (see Appendices E and F) and the control of them has had to be effected with but little increase in the personnel of the Submarine Department. It has been possible to train a few Headquarter Officers in the work and to obtain the loan occasionally of one or two men from the Cable Companies, but the staffing of the ships has frequently been a cause of considerable anxiety.

STAFFING OF  
CABLE FLEET.

12. All applications to the War Trade Department for permission to manufacture and export submarine cable by Cable Manufacturers have been scrutinized by me and many applications to the Ministry of Munitions by Cable

CONTROL OF  
CABLE  
MANUFACTURE.

/ Companies

Companies with regard to "priority" in the manufacture of cable for stock have been referred to me for observations as to the proper class of priority to be assigned. I have thus been able to safeguard the supply of submarine cable required by the British Government or for other work of importance from a military point of view.

In the later stages of the War, owing to the greatly increased demand for cable, an Interdepartmental Committee was formed at my suggestion, to consider the measures necessary for the standardization of cable types, the control of manufacture and the allocation of telegraph and telephone cables. Useful work was accomplished in co-ordinating requirements as to types of cable, methods of manufacture, and in determining relative priorities; but much more might and ought <sup>to</sup> have been done, and I am strongly of opinion that had full powers in these matters been in the hands of the Engineer-in-Chief to the Post Office, a much greater rate of progress and considerable economy would have been effected.

HOME DEFENCE.

Considerable demands have been made for the provision of installations in connection with Aircraft Defences and the following is a brief summary of the work undertaken.

DESIGN OF HOME  
DEFENCE  
INSTALLATIONS.

13. In order to meet the necessary Telephonic and Signalling facilities required for Home Defence purposes special circuit designs, many of them of a complicated character, were prepared. It will be recognised that the progression of events, particularly in regard to those associated with aerial warfare, necessitated the solution of entirely new problems. The urgency of these matters, consequent upon the need for co-ordination of military procedure, rendered the expeditious treatment of these problems essential. In connection with these developments, my Department was called upon to initiate the systems of telephonic control for aircraft defence purposes, after ascertaining from the Military Authorities the actual defensive measures to be adopted. The whole system was kept under constant review, and frequent improvements and elaborations were introduced during the period of the war, with a view to assisting the Military Authorities in rendering their defensive measures more efficient.

The works referred to entailed the design of approximately 150 special circuit arrangements, with the preparation of detailed working diagrams and comprehensive instructions for the use of the staff concerned in the installation and maintenance of the plant.

POST OFFICE  
ADVISERS TO  
G.O.Cs, HOME  
FORCES.

14. At the request of the Military Authorities I arranged early in the War to place the services of eight (subsequently reduced to five) of my Officers at the disposal of the General Officers Commanding the various Armies

and

and Commands in Great Britain as Advisers in dealing with the Post Office Telegraph and Telephone systems in case the Armies might be engaged in active operations in the Eastern Counties. This arrangement contributed considerably to the efficiency of the Defence schemes introduced.

15. Telephone installations were provided at about 450 Gun Stations. The equipment was of a novel and elaborate character, and was required to fulfil special conditions, involving in many instances entirely new designs of communication and in some cases new items of plant.

GUN STATIONS.

Alterations at practically the whole of the Anti-Aircraft Stations due to the evolution of military methods rendered very extensive modifications necessary from time to time.

The total number of circuits exclusive of Fire Observation and Heightfinder circuits, which are referred to separately, was approximately 1800. A considerable proportion of these circuits were lengthy and involved the erection of new pole routes.

16. Approximately 700 circuits for Gun Fire Observation were provided. The whole of the apparatus was specially designed and manufactured for the purpose. The average length of the Fire Observation circuits was  $2\frac{1}{2}$  miles.

CIRCUITS FOR OBSERVATION OF FIRE.

17. About 300 Circuits were provided for use in conjunction with the Military Heightfinder apparatus.

HEIGHTFINDERS.

In each instance where electrical control was used lines were needed for the Recording apparatus; and separate lines, provided with telephones, to secure co-operation between the operators at each end of the base were also required.

Searchlights.



SEARCHLIGHTS.

18. Telephone installations were provided at approximately 600 Searchlights working in co-operation with the Gun Stations. Each installation required on the average three subsidiary circuits, making a total of 1800. In addition to searchlights connected to Gun Stations, 150 installations at Searchlight Stations, used for purposes of aeroplane defence, were provided. Each of these stations was connected either with its own Headquarters or to a Post Office Exchange, from which connection could be secured to the proper Headquarters.

AIRCRAFT DEFENCE  
AND WARNING  
CONTROL  
HEADQUARTERS.

19. Installations of an extensive character were provided at the various Aircraft Defence and Warning Control Headquarters in London, Dover, Chatham, Sevenoaks, Redhill, Staines, St. Albans, Epping, Chelmsford, Portsmouth, Birmingham, Nottingham, Sheffield, Manchester, Liverpool, Leeds, Hull, Grimsby, Middlesbrough, Newcastle and Edinburgh.

At the outset the whole of the equipment was specially designed to meet the known military requirements, but, naturally, the experience gained during actual Air Raids, led to a reconsideration of the whole fighting procedure, which resulted in a much greater elaboration of detail being introduced in the telephonic facilities made available, chiefly with a view to accelerating the despatch of important items of information and military orders. The scheme was built up with a view to the decentralisation of operating duties and rendered it possible to operate efficiently a large number of gun and searchlight stations from an individual control centre.

In addition to the Control Headquarters above referred to, installations of a special character were supplied at seven Command Headquarters in London and at various Company Headquarters in the provinces.

The

P.

The whole of the defensive arrangements required close co-operation between the various control points throughout the country, which necessitated the provision of a complete system of inter-connecting circuits. A large number of these were made available during air raid periods by releasing public circuits, which were rapidly transferred to military service by the operation of special switches previously fitted.

20. Military and Police Observer Posts were provided OBSERVER POSTS, at approximately 450 places in the Observer Cordon. These posts were for the purpose of transmitting intelligence regarding the movements of hostile aircraft.

21. Telephone Switchboard installations were provided AERODROME, ACCEPTANCE PARKS, SQUADRON HQRS., &c. for the Air Ministry at approximately 600 stations, which include Aerodromes, Acceptance Parks, Squadron and Wing Headquarters, Landing Grounds, Schools of Aerial Gunnery and Bomb-dropping Depots, and Stores Depots. These installations varied in magnitude from 10 to 100 lines, and involved the provision of open and underground circuit networks of considerable magnitude, the erection of long distance circuits connecting the more important stations, and, in a considerable number of cases, the utilisation of public trunk circuits.

Nine of the Squadron Headquarters referred to were equipped for Home Defence purposes, viz., Rochford, Biggin Hill, Hainault, Suttons, North Weald, Stow Maries, Detling and Bekebourne. At each of these stations the Air Ministry erected special permanent buildings for the accommodation of the elaborate equipment which was specially designed and installed.

R.A.F.

R.A.F. AEROPLANE  
OBSERVATION  
SCHOOL.

22. A complete installation to be used in conjunction with the training of pilots and observers in aerial gun spotting was installed near Winchester during the latter part of 1917. Special equipment to afford telephonic control, and for the operation of puffing batteries, was designed and manufactured. A very extensive aerial and underground system was also constructed, necessitating an expenditure of approximately 250,000 man hours of labour.

ADMIRALTY  
TELEPHONE  
EQUIPMENT.

23. During the latter part of 1915 when the Anti-Aircraft Defence was in the control of the Admiralty, a special telephonic control system was designed, manufactured and installed at the Admiralty Arch. The equipment consisted of a switchboard for the accommodation of 100 long distant lines, a phonogram room equipped with message stalls, cabinets provided with full interception facilities for the transmission of urgent intelligence to all stations, and special observation facilities for the use of the controlling officer.

Later the growth of telephone long distance traffic from the Admiralty necessitated a study being made of the means by which economies might be effected and an expeditious service rendered. This resulted in a specially designed exchange being installed in November 1918 upon which the whole of the long distance Admiralty traffic is handled. A complete installation of message stalls was also provided, in association with this equipment, for the despatch and receipt of Admiralty intelligence. Observation equipment was designed and fitted with a view to affording efficient supervision in regard to the proper use of these important circuits.

G.H.Q. HORSE  
GUARDS TELEPHONE  
EQUIPMENT.

24. A new Central Battery full multiple telephone exchange, with capacity for 200 lines, and provided with special

special interception facilities for aircraft purposes was installed at General Headquarters, Horse Guards, in May, 1918; and, in addition, three complete and distinct installations of considerable magnitude were specially designed and installed for purposes of Aircraft Defence Control, during the period 1915-1918. In consequence of the evolution of military methods considerable modifications were made to this equipment from time to time, and in the early part of 1918 the whole of the G.H.Q. Anti-Aircraft equipment was re-designed and replaced.

25. A special telegraph office, equipped with Double Current Duplex and Wheatstone apparatus, was also provided at General Headquarters, Horse Guards, in May 1917.

G.H.Q. HORSE  
GUARDS TELE-  
GRAPH OFFICE.

In addition to the circuits which were made permanently available at this Office provision was made for extending a number of important long distance circuits for the purpose of connecting the Military and Garrison Headquarters, and other defensive points, to meet possible hostile eventualities.

26. In order to ensure the restoration of communication on all important Naval and Military circuits which might be interrupted in London as the result of aerial bombardment, provision was made early in 1918, by means of a separate underground cable, in connection with which special switching devices were associated, for the transference of lines from the cable upon which they were normally accommodated to an alternative route.

MILITARY AND  
NAVAL CIRCUITS -  
SECURITY OF  
ROUTE IN LONDON.

27. In consequence of the Zeppelin danger a scheme was developed in 1915 for providing accommodation and equipment for carrying on the work of the C.T.O. in the event of the destruction of G.P.O. West. At G.P.O. South 25 Wheatstone duplex and 5 duplex sounder sets were placed

C.T.O. AIR RAID  
EMERGENCY  
SCHEMES.

in position and sufficient apparatus was held in reserve to equip a further 80 circuits at G.P.O. South, 17 at Threadneedle Street, and 91 at Throgmorton Avenue. Arrangements were also made for deflecting wires at short notice from the G.T.O. to these premises. It was intended to accommodate in an emergency about 600 circuits at Mount Pleasant but, owing to the appropriation of space there by Army Postal Services, it was subsequently found necessary to substitute another scheme for utilising space in the basement of King Edward Building.

To afford greater security in the maintenance of communication on certain important Military circuits during "Air Raids" a special Telegraph Office was opened in October 1917 in the Basement of G.P.O. West. Fifteen double current telegraph sets were installed and the office made entirely self-contained so that traffic might continue to be transmitted even should such a contingency as the destruction of the Central Telegraph Office and power plant arise.

In January 1918 a quick change-over installation for working during Air-raids a larger number of important telegraph circuits was also opened in the Basement of King Edward Building. Fifty-nine sets of apparatus were fitted up including 31 double current sounders, 15 Wheatstone sets, and 8 Hughes sets.

ALTERNATIVE  
LONDON TRUNK  
EXCHANGE FOR  
IMPORTANT  
CIRCUITS.

28. Provision was made in June 1915, for the transference of a large number of telephone circuits needed for Naval and Military purposes to specially prepared equipment at the Museum Exchange. The object of this scheme was to ensure the availability of these circuits in the event of the Trunk Exchange being destroyed by aerial bombardment, and the arrangements provided for the immediate transference of the lines by the medium of special

special equipment fixed in protected situations.

29. At a number of Provincial Centres, special equipment was installed in protected premises for the operation of important circuits in the event of destruction of the main premises, or of their being untenable during bombardment from the sea or air. In connection with these schemes, underground routes were provided in order to ensure greater security.

PROVINCIAL  
CENTRES,  
RESTORATION OF  
COMMUNICATION.

30. In order to provide for the continuation of the telephone service during enemy aircraft raids, arrangements were made for special lighting to be provided at telephone exchanges in vulnerable areas.

EMERGENCY  
LIGHTING AT  
TELEPHONE  
EXCHANGES.

31. For the urgent transmission of the Field Marshal's Air Raid Instructions to Munition and other Factories a number of special circuits were installed, and in other instances existing lines were utilised. To ensure the receipt of these important calls at all times of the day and night it was necessary in many instances to instal loud sounding alarm signals, and experiments were undertaken which resulted in the standardisation of suitable Bells, Buzzers and signalling relays. Special orders were placed for the supply of this class of equipment.

AIR RAID WARNING  
CIRCUITS TO  
MUNITION  
FACTORIES, ETC.

32. At certain vulnerable points on the South-East, East and North-East coasts, underground works of extensive magnitude and of specially deep and solid construction were provided, the important circuits being diverted thereto.

UNDERGROUND  
WORKS AT  
VULNERABLE  
POINTS.

33. A special School of Instruction was established in November 1917 and controlled by the Engineering Department for the training of Military personnel in the maintenance of lines and equipment at Anti-Aircraft Gun and Searchlight Stations. The object in view was to utilise

TRAINING CENTRE  
FOR A.A.  
PERSONNEL.

utilise the services of the men, after being certified as competent, in assisting the Post Office linemen in the upkeep of the installations, particularly at stations in isolated areas. 540 N.C.O's and men received tuition at this training centre.

PROTECTED  
APPARATUS AT  
NAVAL AIRSHIP  
STATIONS.

34. At a number of Naval Airship Stations where provision was made for the manufacture and storage of hydrogen gas, and for the inflation of airships, somewhat extensive systems of telephonic communication and signalling circuits were required. It was necessary specially to design the whole of the plant with a view to eliminating the risk of explosion due to electric sparking in an atmosphere in which explosive gases might be present. Special apparatus was secured for this purpose and the whole of the stations in question were equipped therewith in accordance with the wishes of the Admiralty.

EMERGENCY  
SCHEMES.

35. Emergency Schemes were provided to meet the needs of military operations and transport of troops in the possible event of certain contingencies arising. The total number of circuits involved, which were mostly of considerable length, was approximately 1,000.

Arrangements were made whereby the several portions of the systems could be brought into use within a brief period following a request from the Military Authorities. This provision entailed the earmarking of a large number of public circuits, the installation of interception devices, and the issue of detailed operation instructions for use at all the points through which the circuits were led.

Provision was made for the circulation of the necessary advices by telegraphic and telephonic means, and in order to guarantee the safe transmission of these devices during periods of attack at times when the normal telegraphic

telegraphic and telephonic equipment might be placed out of action special switchboards with operators stalls were provided at a non-vulnerable point, in September 1917. This would enable communication to be maintained by means of ninety circuits to sixty-two important provincial centres.

36. During the week-end period 24th/25th March 1917, upon receipt of Instructions by the Southern Army for concentration of troops on the South East Coast area, emergency measures were taken to equip with apparatus, and bring into service, the whole of the special circuits which had been previously allocated and extended to Defensive Headquarters. The Post Office Stores Depot was opened on the night of the 24th. The whole of the apparatus requirements were telephoned to the emergency officer and the apparatus was assembled and sent to Canterbury during the night by motor van, from which points it was distributed, and fixed in position by the Post Office staff. The greater portion of the circuits was available for service on the afternoon of Sunday, the 25th March.

KENT EMERGENCY  
SCHEME BROUGHT  
INTO USE.

37. At the urgent request of the Admiralty an engineering officer conferred with the Admiral at Dover on the 24th March 1917 with regard to certain Defence measures which were to be undertaken against raids from the sea. A scheme was formulated for operating the necessary range-finders, and controlling the searchlights and newly fortified coast positions erected between Dover and the North Foreland. With the exception of the service to a monitor, which was to be anchored off the coast but which had not then been placed in position, the whole system was completed and in operation within a few days.

KENT COAST  
DEFENCE SCHEME.



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ENLISTMENT OF  
P.O. STAFF FOR  
CO-OPERATION WITH  
R.E. SIGNALS FOR  
HOME DEFENCE.

38. A portion of the scheme prepared for placing Coast Areas under martial law in the event of attempted invasion required the co-operation of Post Office personnel in connection with the maintenance of the existing system of communication and the construction of new lines which might be needed for military purposes.

With the object of assisting the various Home Defence Commands, engineering officers were detailed to act as permanent advisers in regard to telegraphic and telephonic systems of communication. Engineers, Inspectors, and Workmen normally engaged in the areas concerned were enlisted and provided with full kits of equipment, and with instructions as to the procedure to be followed in the event of the emergency arising.

LONG DISTANCE  
CIRCUITS FOR WAR  
DEPARTMENT,  
ADMIRALTY, ETC.

39. For communications required by the War Department, Admiralty and Royal Air Force, approximately 850 public long distance telegraph and telephone circuits were made available for permanent use and approximately 250 were arranged to give a service during the period between dusk and dawn. Some of these circuits were of great length. For instance the telegraph circuit between the Admiralty and the Grand Fleet Base at the North of Scotland required the insertion of three repeaters and had a total length of 696 miles.

BRANCH EXCHANGES  
FOR WAR DEPART-  
MENT ETC.

40. The total number of large Multiple type Private Branch Exchanges provided for the War Department, Admiralty, Royal Air Force, Ministry of Munitions of War, and other Government Departments, for War Services, was 44 comprising 367 Multiple Sections affording accommodation for 23,420 lines.

At the Hotel Cecil, London, a specially constructed C.B. No.1 exchange comprising 41 operators' positions with equipment for 2,000 extension lines and 300 junctions was installed for the Air Ministry and opened

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for working on the 13th March 1917. This installation is probably the largest Private Branch Exchange equipment in existence. This exchange was installed and made available for service in the record time of eight weeks following upon the request from the Air Ministry.

On the occupation of the premises at Kingsway by the Air Ministry a complete inter-communication system with full exchange facilities was installed, the premises being connected to the Regent public exchange where a number of positions were modified in order to provide for the working of the system on a Private Branch Exchange basis.

The total number of non-multiple Private Branch Exchanges provided for the War Department, Admiralty, Ministry of Munitions of War and other Government Departments, for War Services, was 3552, affording accommodation for 64600 lines.

In addition Automatic telephone exchanges have been provided for the Admiralty and Ministry of Munitions as under:-

AUTOMATIC  
EXCHANGES

Date	Name of Exchange	No. of lines.
April 1915	Crombie R.N.O. Depot (Rosyth)	55
October 1915	Rosyth Dockyard	200
July 1916	Gretna Munitions Factory (Wyliss)	175
July 1916	" " " (Blackbank)	175
December 1916	Rosyth Dockyard Extension	200
May 1917	Port Edgar Destroyer Base (Rosyth)	100
October 1918	Rosyth Dockyard Extension	100
October 1918	Port Edgar Extension	50
December 1918	Polmaize R.N.O. Depot (Rosyth)	50

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NUMBER OF  
EMERGENCY WORKS  
CARRIED OUT FOR  
GOVERNMENT  
DEPARTMENTS.

41. From the outbreak of war until 31st March 1919 over 114,000 Emergency Works were carried out for the War Office, Admiralty, Ministry of Munitions, National Service Department and Royal Air Force. Details are given in Appendix G. The statistics contained in this Appendix were compiled weekly and are a reliable record of work carried out in all the Engineering Districts.

APPARATUS AND CABLE SUPPLIES.  
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Enormous quantities of stores for lines and offices, and for extensions to the various sections of the Armies in the Field have been supplied, much of which has been specially designed to meet new requirements as they have arisen.

APPARATUS.

42. In the early days of the War I heard, from officers of the Signal Service, of the need for new types of telegraph and telephone equipment to meet the conditions encountered, and of the efforts that were being made to produce extemporised appliances in the Field. Advice was given to many of these officers, and a few special designs of trench telephones and switchboards which the Post Office could readily produce by utilising apparatus parts and fittings available in its Depots were made up and submitted to the Military Authorities. These designs were adopted by the War Department and the Post Office was asked to issue supplies. Concurrently, a general arrangement was made between the Post Office and the War Department that the former should take over the purchasing and supply to the Armies of the whole of the then existing Military types of telegraph and telephone apparatus which approximated to the corresponding Post Office types. This covered practically all types of equipment which had been prepared for use at Bases, on the Lines of Communication, and in back areas generally, and in this connection I undertook the responsibilities of controlling patterns and specifications, of forecasting demands (in association with the War Office), initiating the placing of Contracts, issuing patterns and specifications to Contractors, discussing requirements

with

with them and furnishing necessary information to Contractors, etc.

With a view to facilitating matters, reducing friction and avoiding the risk of jealousy as between Departments, it was deemed advisable that one of my officers experienced in the design of telegraph and telephone equipment should act as a kind of liaison officer between the Post Office, the War Office and the armies in the field.

Accordingly the officer in charge of my Designs Section was commissioned in the Royal Engineers early in 1916. He has on several occasions visited France and Belgium to study at first hand the requirements of the Armies in the Field and to discuss with the directing and executive officers there the needs of the Signal Service for new types of equipment adapted to the conditions which the development of the War had brought into existence. He has acted as technical adviser and designing officer to the Signal Service on telegraph and telephone matters.

The number of items of special apparatus designed to meet the progressive conditions of War activities is about 200, and the sum of the Contracts placed for their supply exceeds a million pounds. Several hundreds of working drawings and diagrams have been required and as many as 50,000 copies of some of the diagrams have been printed. It may be stated in brief that the designs produced represent the accepted standards for the whole of the new electrical equipment for wire communications issued to the armies for the purposes of the War, with the exception of the proportion of "Fullerphone" instruments designed and supplied direct by the War Office.

The result of the procedure adopted has been that the Engineering Department has fulfilled, in the matter of Military supplies, precisely the same functions of

initiation

results I visited, together with Mr. Morgan, the works of certain of the Wire Drawing Firms. The signing of the Armistice however rendered further progress in this matter unnecessary.

EXAMINATION OF APPARATUS AND STORES FOR WAR DEPARTMENT.

45. Under an arrangement made with the War Department in 1915, that Department agreed to use wherever possible Post Office types of telegraph and telephone apparatus and line stores and the Post Office undertook to purchase, examine, test, and supply stores of this type, and also of the War Department's standard types, and subsequently of types specially designed by this Department for the Military Authorities. The following statement shews the approximate value of the War Stores so inspected and reported on:-

Year	Approx. value of stores examined & tested by the Engineering Dept. for the War Dept.	Percentage of total value of all stores examined by the Engineering Department.
	£	
1914-15 - (8 months)	367,000	20
1915-16	527,000	30
1916-17	1,807,000	60
1917-18	3,109,000	80
1918-19	3,667,000	75
TOTAL	9,477,000	

RADIO - TELEGRAPHY.

Throughout the War this Department has co-operated freely with the War Office and Admiralty in Wireless work.

46. Within two or three days of the outbreak of War 2916 licensed and 800 unlicensed stations were dismantled and closed down. In addition recovery was effected in 1300 cases where component parts of wireless apparatus were held in contravention of the Defence of the Realm Regulations. In July 1915 the whole of the wireless apparatus of private individuals was removed into Post Office custody.

In cases of prosecution by the Military and Police authorities for breaches of the Defence of the Realm Regulations in regard to holding wireless apparatus, expert evidence was given by my Engineers.

At the request of the Admiralty, this Department exercised control and supervision over the wireless activities of Messrs. Siemens Bros. from September 1914 until May, 1918, and at the request of the War Office the works of Messrs. Isenthal have also been supervised since September 1914. This Department also undertook the examination of the premises and books of 82 firms, who had been granted permits by the Postmaster General to manufacture and sell wireless apparatus, in order to ensure that the conditions governing the permit had been complied with.

All orders for wireless supplies coming under the review of the War Trades Department and the Commission Internationale de Ravataillement have been scrutinised in this Office.

47. In September 1914 an Interdepartmental Committee considered the steps to be adopted for the detection of illicit wireless signalling. A scheme was prepared by the Post Office and accepted by the Committee and at the request of the Committee the Post Office undertook the work. In all 22 "detecting" stations were equipped in connection with the scheme. The special sets required for the work were made up in this Department's Wireless Laboratory.

SEARCH FOR  
ILLICIT SIGNALS.

The system was maintained till February 1918 when the responsibility was taken over by the Admiralty.

The information obtained from these stations has proved valuable to the Naval and Military Authorities in drawing attention to irregularities at their stations, and in giving particulars of signals otherwise unknown to these Authorities.

Assistance has been given from time to time to the Army, Navy, and Police Authorities in investigating reported cases of illicit signalling.

INTERCEPTION  
OF ENEMY  
SIGNALS.

48. The special interception of enemy signals was performed for the Admiralty at the Bolt Head Station from January 1915 to January 1918, at the G.P.O. Station from August 1915 to December 1917, and at Stonehaven from October 1916 to February 1918. Interception work has also been performed for the War Office at Caister station since January 1917. The apparatus used for this work was designed and made in the Wireless Laboratory.

As an example of the work accomplished in this direction the following case may be mentioned. In January 1918, peculiar signals of enemy origin, consisting of dashes rising and falling rhythmically in strength, were heard by the Post Office Staff at the Direction Finding Stations to which no intelligible signalling code could be assigned. The problem was considered by the various Departments, but its solution was effected by my officers. Apparatus was designed for obtaining graphical records of the signals and from these it was ascertained that the Germans were using a system of wireless location indicators. It was shown that by observing the sequence of signal strength from two stations with reference to fixed times enemy units were able to determine their position.



49. A school for training Flying Corps Units in theoretical and practical wireless work, and accommodating from 200 to 250 men, was equipped and organised at Farnborough, Hants. Two of my officers were appointed Director and Assistant Director of Studies at the School with Commissioned rank. The apparatus there has been maintained by the Department.

WIRELESS SCHOOL  
FOR FLYING CORPS.

50. In August 1916, the work of localisation of enemy aircraft by Wireless Direction Finding was undertaken by this Department for the War Office and for this purpose three stations (Seaham Harbour, Peterborough and Westgate) were equipped and opened in December 1916. A fourth station, at Falkirk, was erected solely by this Department and added to the system in September 1917.

DIRECTION FINDING  
STATIONS.

Enemy aircraft were mainly navigated by means of wireless signals. An aircraft wishing to ascertain its location would signal to its land control station, and thereupon observations at two or more complementary direction finding stations were made of the aircraft's direction. The control station would ascertain from these directions the location of the aircraft and advise him in code by wireless accordingly.

Observations were made at our direction finding stations as soon as aircraft commenced to signal; their location was therefore made known to us at the same time. The directions of the aircraft were wired to the War Office (Intelligence Department) by direct wires from the direction finding stations and plottings made by the Intelligence Department for the locations.

The chart marked Appendix P which has been prepared from records in this Office is a typical plotting and shows roughly the courses of Zeppelins during the raid of the night of May 2nd.- 3rd 1917 when one of the Zeppelins was wrecked in Stavanger Fiord. The dotted lines in the

\* Furnished to  
Secretary only.

routes indicate those parts of the routes over which no wireless signals were used, hence no definite locations could be made. Each line is a Zeppelin's course and different coloured lines are used to indicate the several Zeppelins. The crosses in the lines are the points where signalling occurred; and against these points are shown the particular Zeppelin's code and time of signalling.

On one occasion observations of the directions of a Zeppelin made at the Seaham Harbour station were constant in direction showing that the Zeppelin was travelling in a line passing over the station. Bombs were seen to drop on the seaward side of the station, the Zeppelin was visually observed to pass over the station and few moments later bombs were seen to drop on the landward side of the station. The experience was most exciting for the staff, but they remained at their posts and continued to take observations of other Zeppelins taking part in the raid.

In addition to the work of localisation of enemy aircraft the stations were used to locate the position from which any unaccountable signals in this country were received. In 1918 much disturbance was caused at the War Office by the reception of very powerful wireless signals, which were definitely located by our direction finding stations to the neighbourhood of Esher. Home Forces were on the point of requisitioning the services of a large body of police to hunt down the delinquent. The Commissioner of Police, however, referred to the Post Office, and from further information at our disposal it was definitely established that the signals emanated from an experimenter working for the Ministry of Munitions at Claremont Park, Esher, who was working outside the conditions of his permit. The police were thus relieved of a large amount of work and the offender was duly brought to book by his Department.

On numerous occasions congratulations have been received on the accuracy and promptitude with which information has been furnished to the War Office. Latterly the utility of the stations has been extended to training Army units in wireless direction finding work.

51. A new type of Direction Finding Gear was designed and proved in the Wireless Laboratory, and reached its final stage in September 1918, but the early conclusion of hostilities militated against its adoption by the fighting forces. The invention, however, received high commendation from representatives of the Admiralty and War Office who have seen the gear working in the Wireless Laboratory.

NEW TYPE  
DIRECTION  
FINDING  
GEAR.

52. Increased wireless receiving facilities were provided in 1917 at Valencia, Malin Head, Crookhaven and Cullercoats, and new stand-by power transmitting sets at Valencia, Lands End, and Malin Head to meet Admiralty requirements in connection with the Anti-Submarine campaign.

SHIP &  
SHORE  
WORK

53. Considerable work has been involved in meeting the numerous demands for substantive circuits to link up the various Wireless Stations with the general telegraph system. In all about 50 separate circuits were provided. Much of the work was done in isolated localities and many of the circuits connected points extremely remote from each other. For example the circuit serving Lizard W.T.S., Mount Wise Naval Centre, Milford Naval Base, Linney Head W.T.S., Liverpool Naval Centre, Rhyl W.T.S., and Amlwch W.T.S. and W.S.S. has a mileage of 716 miles.

SUBSTANTIVE  
CIRCUIT  
CONNECTIONS  
BETWEEN W.T.  
STATIONS.

## RESEARCH.

Many problems arising out of the War and involving much Research work have been referred by the War Office and Admiralty to this Department for consideration, and notwithstanding the very limited laboratory accommodation at our disposal we have succeeded in many cases in obtaining excellent results.

### RESEARCH WORK FOR WAR OFFICE

#### SOUND RANGING MICROPHONES.

54. In September 1916 the Director of Field Works and Fortifications, War Office, requested my assistance in developing a promising experiment carried out with crude apparatus on the battlefield which had for its object the locating of the positions of enemy guns. After a few weeks of assiduous work the desired solution was obtained and by means of special electric furnaces and novel laboratory equipment, which were designed and constructed in this Office, the first satisfactory microphone was produced. Since then about 23,000 of these microphones have been made by my Officers for the use of the Military Authorities. The object of sound ranging is the location of hostile guns by calculations based on the differences between the time intervals required for the sound of the gun discharge to reach each of a series of the microphone detectors, placed at measured intervals near the Army Front. These time differences are recorded by electrical means upon a photographic ribbon film. The system is also used to calibrate guns by locating in a similar manner the actual points where the shells burst. It was officially reported at G.H.Q. that over 80% of all enemy gun positions located were found by means of these microphones, the balance being found by Aeroplane observation and

"flash

"flash spotting". On the 1st August 1918 I had the honour ROYAL VISIT, of taking Their Majesties The King and Queen through my Research Laboratory where the microphones were being made. They manifested a keen interest in the various processes of manufacture and were glad to know of the assistance we were giving to our Armies in the Field. The personal thanks of Sir Douglas Haig have also been received for this work. A copy of his letter to the Postmaster General is enclosed (Appendix I).

Particulars of other items of apparatus used in connection with Sound Ranging and designed and provided by this Department are given in Appendix H.

55. Early in the War the same department of the War Office desired to procure hypersensitive telephone transmitters for placing on the parapets of the enemy trenches at night. A suitable design was evolved and a small supply sent out. An improved design of double microphone was shortly afterwards produced for use binaurally giving increased sensitivity and a sense of sound direction and a large number of this type have been supplied by the Post Office for installation in prisoners' huts. Similar microphones made up in a portable form have been supplied to the Civil and Military Police Authorities.

HYPERSENSITIVE  
TELEPHONE  
TRANSMITTERS  
&C.

In addition a series of experimental researches has been carried out for the same Department on the following subjects:-

Working limits of signalling apparatus and Field Cables in general use.

Tables and Curves of working limits for Signal Officers.

Selective Reed Relay for Earth Signalling.

Experimental Investigations on the use of Fuller-phone Buzzer Set.

Magnets for Buzzer Sets.

Transmission efficiency of Trench, Telephone apparatus, Navyphones, Anti Aircraft Circuits etc.

Efficiency of signalling apparatus captured from the German Army.

SPECIAL  
APPARATUS  
FOR MILITARY  
INTELLIGENCE  
DEPARTMENT.

56. In October last a request was received from Military Intelligence for assistance in the design and manufacture of confidential apparatus for use in enemy countries. This apparatus was urgently required; its production involved a certain amount of research; a supply of special materials strictly reserved for war purposes; specialised technical skill; and manufacture under conditions of secrecy. A small building was found in a country district in an isolated position, converted into a working laboratory, fitted with electric power and an adequate supply of the required apparatus delivered to the War Office within 14 days of receiving the request.

After the Armistice early forms of the apparatus <sup>were</sup> made the subject of further research at the request of the Military Authorities and important improvements effected. The manufacture of the more secret portions of the apparatus was actually carried out by two sappers of the Royal Engineers under the instructions of my Research section.

I understand that the first batch of these devices was sent by special messenger to France and ultimately to enemy territory where they were used to great advantage.

PALESTINE  
TRAIN  
SIGNALLING  
SYSTEM.

57. At the request of the Director of Railways, War Office, an investigation of the working limits of

a system of train signalling for Palestine Railways was undertaken in the Autumn of 1918 under circumstances of urgency and a report furnished to form the basis of a specification for equipment.

58. For the Royal Engineers (Signal Service) various designs of trench signalling apparatus were produced and a series of experiments carried out with the object of improving existing methods; an oscillographic study of standard Trench Wireless Telegraph set was carried out when the apparatus was in its experimental stage and the results communicated; and critical technical examinations were made of captured German field telegraph apparatus.

EXPERIMENTS AND TESTS WITH SIGNALLING APPARATUS.

59. When the enemy's submarine activity first assumed serious proportions I was approached by the Admiralty Board of Invention and Research for assistance in developing a new type of apparatus for use in non-contact sea mines and as a result of special efforts two working models were developed which operated at effective distances on the approach of a submarine. A slight modification of one of these models was finally adopted as a ground mine and put into service.

RESEARCH WORK FOR ADMIRALTY  
APPARATUS FOR USE IN MINES.

Valuable assistance has also been given in connection with the design and specification of apparatus for operating a moored mine at a distance on an acoustical principle. The examination and approval of the very delicate apparatus used in these mines, of which a great number have been ordered, has been by special request of the Admiralty entrusted to my Research Section.

60. The question of signalling through the sea without cables was studied and the theoretical conditions necessary for successful use of this method for

SIGNALLING THROUGH THE SEA WITHOUT CABLES.

communication with submerged vessels or between surface vessels or between ships and shore were deduced and fully reported upon in November 1915 including the previous history of Post Office experiments. This report was subsequently extended to a series of conduction experiments through the ground for the information of the War Office which greatly facilitated a knowledge of the best conditions for maintaining communication with advanced outposts in the War area.

SUBMERGED  
ELECTRODES IN  
ANTI-SUBMARINE  
DEFENCE.

61. Another case which was referred to this Department for consideration related to a proposal which had been received by the Board concerning defence against enemy submarines in river estuaries and shallow coastal waters by utilising the change which takes place between submerged electrodes when a vessel passes near them. This scheme was experimentally tested on a small scale in February 1917 with apparatus of our own design and the limitations of its use pointed out. The Board came to a decision on our report of the experiments.

Assistance has also been given to the Board in numerous other directions.

EXPERIMENTS  
WITH  
AMPLIFIERS.

62. In September 1918 the Civil Engineer-in-Chief of the Admiralty sought my advice as to the use of Thermionic Valve Amplifiers in association with certain submarine detecting devices intended for use as part of the cross-channel barrage scheme and one of my officers was deputed to assist Admiralty officials with preliminary experiments carried out in a large fresh water lake at Slapton near Dartmouth and in the sea between Dartmouth and Salcombe. The experiments

covered



covered a period of about a month and the assistance given was acknowledged by the Admiralty officials as being valuable in the development of their scheme.

63. In December, 1916 shortly after the outbreak of enemy submarine activities, a scheme devised by one of my Staff Engineers for locating the position of hostile submarines, by specially designed acoustical receivers fixed in a submerged torpedo shaped vessel to be towed behind a ship, was placed before the Admiralty and shortly afterwards the Anti-Submarine Division requested this Department to develop the scheme and co-operate in testing other inventions and proposals submitted to the Admiralty.

SUBMARINE HUNTING RESEARCH FOR ANTI-SUBMARINE DIVISION.

The Post Office scheme was designed to detect the presence of an enemy by the sound waves emitted in water by its machinery and propellers; to cancel out disturbing sound waves from the pursuing vessel; and to measure accurately the angle of incidence of the sound waves for the purpose of determining the position of the enemy. The solution of this problem involved three distinct lines of investigation, viz:-

1. Acoustical transmitters faithfully reproducing the phase of sound waves received by them from the water.
2. Accessory electrical apparatus for measuring phase differences of electrical currents generated by the transmitters.
3. Naval apparatus and gear for placing the transmitters in the sea, and towing them at the required depth under the surface.

Exhaustive experiments under each of these heads were necessary to overcome the unusual difficulties met with, but a short time before war activities came to an end, the three phases of the problem taken separately were satisfactorily solved.

solved. Our estimate of the apparatus required and of the difficulty of the problem was borne out by the experience of the war which proved the ineffectiveness of all acoustical apparatus directly attached to the hull of ships. Our conclusions were further confirmed by the fact that the most useful acoustical devices used in naval war including those imported from the United States were based upon our scheme of towed receivers. Unfortunately complete success was not attained by any of the acoustical devices of which we had information and the naval war ended with the practical elimination of all but two inventions in this field of investigation i.e. the acoustical system developed by the Post Office and the so-called supersonic system which was proposed about the same time as the Post Office acoustical system and which has been under development by selected scientific workers under Admiralty control for the past three years.

The operation of the supersonic system is analogous to a search light beam under water giving reflection when it strikes any body having physical constants different from those of water. It is capable of being used in the presence of a convoy of ships where an acoustical system would be useless and its effectiveness is only less than a search light above water at night by reason of its shorter range.

The present position of the Anti-Submarine problem so far as it affects Post Office experiments is briefly as follows:-

1. Under water acoustical methods of hunting a submarine, or conversely enabling a submarine to defend itself or attack without coming to the surface, has not been satisfactorily solved apart from the Post Office system developed during the war.

2. The apparatus developed by the Post Office fulfils all the known physical conditions required for a satisfactory solution of the problem and the Admiralty have since the Armistice asked for the ship experiments to be continued at one of their testing stations.

3. The supersonic system is according to our confidential information highly successful for short ranges, but it has limitations which the acoustical system is capable of bridging over, the two systems acting as complementary to each other. For an enemy using his propeller the acoustical system has the longer range.

4. Further experiments by the Post Office are awaiting the delivery of additional apparatus when it is expected the system can be further demonstrated at Portland and handed over to the Admiralty in working order.

The experiments undertaken for the Admiralty have yielded results of considerable value to the Post Office in the development of hypersensitive telephone transmitters of two distinct types. One of these types is a faithful reproducer of the phase of sound and promises to become a practically invariable standard for speech transmission, a result which has been aimed at since telephony became a large business but which has never been realised before. It is remarkably robust; it has no adjustments; its sensitivity as a transmitter is capable of being increased to any desired extent by amplifying valves; and its power as a receiver or reproducer of sound can also be magnified to any extent desired.

The Admiralty placed a Motor launch at our disposal for towing experiments which were carried on in the Thames estuary from our Submarine Cable Depot, Woolwich, during the last 18 months. By this means the purely naval part of the problem was satisfactorily solved and our designs largely copied for experiments at other Admiralty stations. The crew of this launch has now been demobilised and any further sea experiments required will

be carried out at ~~the~~ stations.

Our work for the Admiralty has been ~~carried out under~~ exceptionally urgent conditions involving very extended hours of work. In the last year of hostilities 93 drawings and 53 new designs in connection with the submarine problem alone were actually produced and apparatus ~~manufactured~~ manufactured in the endeavour to find a satisfactory solution in the most expeditious manner.

ELECTRO-MAGNETIC INDUCTION DEVICES.

64. Another of my Staff Engineers devised two ingenious schemes for detecting submarines. One of them consists in laying a loop of Submarine Cable for a distance of a few miles from the shore in an infested area and using electromagnetic induction apparatus to reveal the passage of a Submarine and indicate the direction in which it is travelling. The suggestion was seen to offer considerable possibilities and after its feasibility had been demonstrated by experiment the Admiralty it is understood utilised the idea in practice. The second device consists in providing a large coil of wire on a suitable vessel in order to locate a submarine. Apparatus connected to the coil is operated by the magnetic field of a submarine. Considerable difficulties were encountered in carrying out the experiments but some measure of success was achieved and the matter was I think followed up by the Admiralty.

RESEARCH WORK FOR THE AIR FORCES.

AIRCRAFT MAGNETO IGNITION MACHINES.

65. In November, 1916, this Department undertook for the Director of Aircraft Equipment, War Office, urgent tests of an exhaustive character of new types of magneto ignition machines proposed for use in Aircraft and carried on this work for some months until the Air Board were able to establish laboratories to meet its requirements

requirements. All the existing types of magnetos were investigated and fully reported upon.

66. In November, 1917, the Inventions Department of the Ministry of Munitions set up an Acoustical Research Laboratory at Imber Court, Thames Ditton, in connection with anti-aircraft developments, and sought the assistance of this Department in procuring supplies of special research apparatus and sensitive microphones of the type supplied for sound ranging. About 1000 special microphones of various types have been supplied for research purposes on aircraft location.

MICROPHONES  
ETC. FOR ANTI-  
AIRCRAFT  
RESEARCH

67. The Royal Naval Air Service required a telephone system for installation in Airships for communication between the various positions. Researches were carried out by my Staff on various types of Airships which resulted in the evolution of a system necessitating a special switchboard and outstations with calling facilities and capable of operation under severe noise conditions. The apparatus is gastight to exclude inflammable gases.

AIRSHIP  
TELEPHONES

This apparatus has been adopted as standard on all rigid Airships and other special telephones have been installed in N.S. type Airships.

Equipment for 140 outstations for rigid ships has been manufactured and supplied by the Post Office.

68. A system of communication between the pilot and crew on aeroplanes has also been developed on the omnibus circuit principle. The chief difficulty lay in preventing the abnormal extraneous noises reaching the listeners ears, either by direct or telephonic means. This has been accomplished by enclosing the receivers in spongy rubber cups and the evolution of a transmitter

AEROPLANE  
TELEPHONES.

practically

practically insensible to air transmitted sounds and sensible only to speech imparted to it by contact with the speaker's throat.

Apparatus for about 5,000 stations has been manufactured, partly at the Post Office factories and partly by outside Contractors.

Attempts are now being made to use such a transmitter for both inter-communication and wireless telephony. A special circuit has been evolved which enables the same receivers to be used on both circuits, without switching, and does not involve any interaction between the two systems. This circuit has been adopted by the R.A.F. for general use.

#### KITE BALLOON TELEPHONES.

69. The Air Forces also required telephones for use between the occupant of the balloon basket and earth when solid steel balloon cables were used, capable of working both over a metallic circuit formed by the balloon cable and an insulated core and over a single wire circuit. After some research, including measurements of the capacity between the balloon cable and earth an instrument was evolved capable of fulfilling the conditions and superior to any previously used apparatus. This has been adopted as standard and about 3,500 sets have been ordered and supplied by the Post Office factories and outside contractors.

#### STEERING INDICATORS.

70. The R.A.F. required some means of signalling to the pilot of large aeroplanes from a distant point in the machine, the compass course to be steered. A simple and light weight electrical device built on telephone signalling lines has been evolved and adopted by the R.A.F. and arrangements have been

made

made for the supply of 70 by the Post Office Factory.

71. The effect of low temperatures on the capacity of secondary cells during high altitude flights was investigated for the R.A.F. and the results communicated.

LOW TEMPERATURE  
AND SECONDARY  
CELLS.

72. Assistance was given in the design of a telephone switchboard for controlling connections between artillery positions and a Kite Balloon towed by a tank.

TANK SWITCHBOARD.

73. In connection with experiments on Aircraft Engine Noise an Oscillograph for use on Aircraft was designed.

AIRCRAFT  
OSCILLOGRAPH.

74. A complete set of transmission apparatus was standardised and supplied for use of R.A.F.

TESTING  
APPARATUS.

A number of minor tests were also carried out including the efficiency of various captured telephone sets from Zeppelins etc.

In connection with aircraft research one of my officers has taken part in over 100 flights in various types of aircraft.

75. On the cessation of hostilities the Lords Commissioners of the Admiralty, in a letter to the Postmaster General, expressed their thanks to me for the special assistance given in connection with experimental and research work for the Navy during the War and to the Staff of this Department for important help rendered in regard to similar matters. In addition the Board of Invention and Research and the Air Board have expressed their appreciation of the careful

APPRECIATION.

and

and exhaustive research made in this Department and of the important contributions to the elucidation of complicated and difficult problems.

A letter of thanks has also been received from the Ministry of Munitions in connection with our assistance at Imber Court.



G E N E R A L

EARLY PRECAUTION-  
ARY MEASURES.

76. At the outbreak of War, and for some time subsequently, it was naturally expedient to adopt measures for protecting the Department's telegraph and telephone plant from damage by enemy agents. Much consideration and foresight were necessary in this connection and there is little doubt that the steps taken contributed to the satisfactory maintenance of communication.

It was considered that one of the vital points of attack was the G.P.O. West building in which is housed the Central Telegraph Office and a very considerable portion of the Department's electric light generating plant. For the partial protection of this important building and more particularly for the protection of the Basement Test Room which extends under the footway and roadway in Newgate Street, and into which the telegraph wires to all parts of the world are led, I arranged for a screen of expanded metal <sup>(See Appendix I C)</sup> to be provided over the area surrounding the building the primary object of which was to prevent a hand bomb from being thrown into the area. All means of access to the basement were closed or otherwise guarded. In the early days of the War air-raids were not seriously anticipated, but as will be seen from Section 84, the utility of this screen was demonstrated on the occasion of bombardment from the air. Arrangements were also made for a military guard to protect the building in addition to the Commissioners; for permits to be issued to workmen employed near the building; for the public convenience in St. Martins le Grand to be closed and covered by an expanded metal screen on account of its close proximity to the Department's underground plant; for the building

to be darkened (by the drawing of blinds etc.) after sunset; and for all unknown callers at G.P.O. West to be conducted personally to the officer or officers required by them. Indeed, the details of the arrangements were such that even officers of the Engineering Department were requested to assist the Military and Police in their measures for the protection of the building by refraining from standing about in the adjacent streets when on their way to and from the Office.

Arrangements were made for patrol of telegraph and telephone lines by Police, Special Constables, Members of the Automobile Association and Boy Scouts; the provision of guards for Submarine Cable Depots and Submarine Cable Huts etc; the provision of Special Constables for the protection of P.O. buildings, Test Huts, etc; the supply of armlets (in certain areas) and pass cards to workmen authorised to visit P.O. premises, to work on P.O. lines or to open manholes. Close cooperation between the Superintending Engineers and the Police and Military authorities was maintained.

Special attention was also devoted to the subject of attempted injury to or illicit tapping of wires; and incidents of this nature were carefully investigated.

77. The conditions which arose out of the War, viz: EXPENDITURE financial stringency, increasing shortage of labour consequent on the enlistment of workmen, and restrictions on the supply of materials, necessitated rigorous cutting down of the Engineering Programmes. Arrangements were made to reduce the expenditure on Maintenance to the minimum requisite to keep the systems working in order that as many men as possible could be released either for Military service, or for the purpose of providing the War Emergency communications required by the Admiralty, War Department,

Department and other Government Departments. As these communications were very numerous and urgently required, the ordinary routine adopted in connection with the provision of circuits for these Departments had to be modified. Special arrangements for the purpose of simplifying the accounting procedure in connection with their provision and rearrangement were made.

Appendix J shews the expenditure year by year on War Engineering Works. (See Appendix Q... for general particulars of expenditure in connection with the Annual Programmes).

#### CONTRACTS.

78. In the early months of the War contracts were affected in three main respects, viz:-

- (1) difficulty in completing current works owing to depletion of labour, resulting in the contract periods for completion being exceeded;
- (2) increased cost of work on current contracts, resulting in some cases in alleged net losses to Contractors, due to disturbed labour and material conditions; and
- (3) a marked decrease in the number of works put out to contract.

As regards (1) 232 cases of delay in completion were investigated during the year 1915-16 and 196 during the following year.

Under (2) numerous requests were received from Contractors for increased prices to be paid to them, and these were carefully investigated with a view to their being accorded equitable treatment.

With reference to (3), during the year 1915-16 the number of contracts placed was 327 as compared with 724 let during the preceding financial year. Appendix K

shews

shews the number and estimated value of the various classes of contract placed during the War period in comparison with the figures for the financial year 1913-14. The majority of these War-time contracts were of course for War Services and other services of National importance.

The inauguration of the Ministry of Munitions (early in 1916) considerably increased the Department's difficulties in contracting, for in framing the majority of contracts the rules and requirements of the Ministry in relation to labour and materials had to be conformed to. These rules and requirements were briefly as follows:-

The labour employed by "Controlled" Establishments engaged upon the production of Munitions of War was so regulated and apportioned by the Ministry (Priority Department) that every contract placed with those establishments was classified, by agreement with, or in accordance with the rules of, the Ministry, according to its War or other National urgency. The classification accorded to any Contract determined the order in which it was executed in relation to all other Contracts for the time being held by the "Controlled" Establishment.

Control of Labour.

Having regard to the National situation, the utmost care had to be exercised in this Department to prevent the allocation of any work to a Priority Class, or subdivision thereof, higher than that which the circumstances justified, but at the same time to secure the priority appropriate to its importance. During the years 1916-17 and 1917-18, 640 cases were thus classified.

The Ministry of Munitions exercised control over the supply and distribution of steel, copper, brass, and other materials employed in the manufacture of Munitions of War, and certificates or permits had to be obtained from the Ministry or issued by this

Control of Material.

Department

Department for the employment of such materials on specific Contract work. The Minister not only required to know the exact requirements in metals of each Government Department, but called for periodical forecasts of these requirements covering six and twelve-monthly periods. These forecasts had to be frequently reviewed in order that the Ministry might make suitable provision, and keep entirely up to date with this Department's requirements. As the control of materials grew more stringent it became necessary for priority certificates to be issued for all works, including maintenance, repair, and renewal works, in connection with which "Controlled" materials were required. With a view to preventing delay in putting in hand maintenance, repairs, or renewals of running machinery and plant the Ministry were requested to grant general permits enabling this Department to issue in respect of such works its own Priority Certificates, thus obviating the necessity for making application to the Ministry in each case for a Permit. These general permits were granted, and considerable expedition in putting work in hand resulted.

Licenses for  
Works of  
Construction or  
Engineering.

On 14th July 1916, the Minister of Munitions issued an order under Defence of the Realm Regulations precluding the commencement or carrying on of any building or construction work or other work of construction or engineering estimated to cost more than £500 without a License from the Ministry. Works under Contracts entered into by any Government Department were exempt from the necessity for obtaining a License; but by arrangement with the Ministry and at their request, the Ministry had to be notified by this Department of every contract work the cost of which was estimated to exceed the sum of £500. Notification was sent at the time each contract was placed.

In December 1917, the Works Construction Sub-Committee of the War Priorities Committee was formed, and this Department was required to seek the prior concurrence of the Sub-Committee in the execution of all works except those of "extreme urgency", estimated to cost £5,000 or over. Works estimated to cost over £1,000 and under £5,000 had to be notified to the Sub-Committee as they were put in hand.

The Ministry of Munitions established a Central Clearing House in order to centralise information regarding machinery required by firms engaged on Government contracts; and it was arranged at the request of the Ministry that in issuing invitations to tender for work which would involve the use of machinery, this Department would require tenderers to state, in submitting their tenders, whether they would undertake, should the contract be placed with them, on behalf of themselves and their sub-contractors (if any) that no additional machinery would be required to execute the contract; or, alternatively, what additional machinery they would require, the information so obtained being forwarded to the Ministry.

Machinery in "Controlled" Factories and Workshops.

From 1917 onwards considerable difficulty was experienced, both in regard to tenders and contracts, owing to the fluctuating but generally upward tendency in rates of wages and in prices of materials, and the consequent prevailing contractual uncertainty. Cost Variation Clauses had to be drafted to provide for the adjustment of contract prices affected by such fluctuations. The Clauses being drawn on an equitable basis went far to remove the speculative elements in war-time contracting.

Cost Variation Clauses.

79. A very considerable amount of work has necessarily arisen in connection with the arrangements for the

ENLISTMENT OF ENGINEERING STAFF.

release of men for the Army. The following is a brief resumé of the outstanding features.

At the outbreak of War a very large number of Territorials and Army Reservists were liable to be mobilised and at first it was found necessary in certain cases, to retain on civil duties under War Office authority a number of such men who were not members of signal units and for some time it was thought desirable to restrict the enlistment of Engineering Department men to the signal units of the Royal Engineers. In April 1915, however, the position with regard to construction work permitted the release of a number of men for ordinary units as well as for the Royal Engineers (Signal Service) and from this time onward a very large number of men were enlisted, the majority entering the Royal Engineers by means of special certificates issued through this office.

At the end of October 1915 the Postmaster General issued a special recruiting appeal in connection with Lord Derby's attestation scheme of voluntary enlistment and the correspondence arising out of the recruiting scheme involved a great deal of urgent work. I was called upon, at a few hours notice, to select 2,000 workmen to form a waiting list for the Royal Engineers the intention being to allow any others who could be spared to enlist in combatant units.

The Military Service Act, Session 1, came into operation in March 1916 and rendered liable for Military Service all single unattested men between 18 and 41 years of age. Following this it was necessary to issue certificates of exemption to such unattested single men as were required for retention in the Engineering Department.

The Military Service Act, Session 2, came into  
operation

operation in June 1916 and as a result all unattested men whether single or married, between 18 and 41 became liable for Military Service. A further issue of certificates of exemption was necessitated and later on in the year certificates of exemption were issued both to unattested and attested men of Military age. The certificates in the case of unattested men were valid for very short periods and a considerable amount of work was involved in their despatch to and from the Secretary's Office for certification.

In April 1918, owing to the large number of enlistments in the Army of men who had not obtained official permission to leave their civil duties, a warning leaflet had been issued by the Postmaster General to all Engineering workmen warning them that under pain of dismissal they must not enlist in the Army without the permission of the Department. The large number of cases of enlistment without permission prior to the issue of the leaflet were subsequently reviewed and in a large proportion of the cases civil pay was eventually allowed. In August 1918 the whole of the cases of men, excepting temporary employees, who had severed their connection with the Department by enlistment without permission were enquired into and re-instatement was effected in many instances. The work involved was considerable.

The severe storm of 27th and 28th March 1916 (see Section 90) had such a disastrous effect upon the Department's plant that it was found necessary to stop the enlistment for the Army of all men who were fitted for storm repair work and it was not practicable to withdraw this restriction until April 1917. The consequence was a very material reduction in the number



of men enlisted. Whereas during the year ended 31 March 1916 4641 men of all grades were released for naval and military service it was only possible during the year ended 31 March 1917 to release 1439 men. Temporary exemption had consequently to be sought in all cases of retained men of military age.

Owing to the frequent cases of resignation of Skilled Workmen in the Electric Light Staff, it was found necessary to withhold the issue of "leaving certificates". In such cases, arrangements were made for bringing the matter where necessary before a tribunal constituted under the provisions of the Munitions of War Act 1915.

In the latter part of 1916 the question of allowing men employed in this Department to join the Volunteer Training Corps was raised and in a few cases it was decided in the interests of the Service to withhold permission.

The treatment of Conscientious Objectors to Military Service who were in the service of the Engineering Department gave rise to a very considerable amount of correspondence.

Early in 1917, owing to the efforts of the War Office to comb out from Government Departments and from private industries men under 23 years of age by the cancellation of exemption certificates, the question of the Department's position arose in this connection. The matter was complicated by the need for the retention of men for Storm repair work but eventually the release per month of a definite quota of young men was arranged for in certain Districts. In April 1918 however I convened a meeting of Superintending Engineers, at which the Secretary was present, for

the

the purpose of emphasising the need for the release of all young men, and as a result a substantial increase in the monthly quotas of men was effected in all the Districts.

The Military Service (Review of Exceptions) Act 1917 which provided for the re-consideration of a number of cases of men hitherto regarded as exempt from Army Service occasioned a considerable amount of work due to the number of medical re-examinations which were necessitated.

In October 1917 it was decided to transfer to the Army Reserve W all telegraphists, ex telegraphists and Engineering workmen eligible for Military Service. The transfer of the men to Army Reserve W involved in nearly every case a visit of the men to the Recruiting Officer and the whole work involved a very considerable amount of correspondence.

The Military Service Act No.2 1918 rendered liable for Military Service men up to 51 years of age and Engineering workmen of the new Military age were in due course transferred to Army Reserve W.

Later on particulars were forwarded to the Secretary in connection with all other men of the new Military age for whom it was proposed that certificates of exemption should be issued.

Appendix L shows graphically the number of workmen below the rank of Inspector, employed in this Department during the War, the number of Workmen released for Military and Naval Service, and also the number of Female Assistants taken on as substitutes.

The total number of staff of all grades released for War Service excluding 106 members of K. Telegraph Co. R.E. was 12,877 (See Appendix K) approximately 51% of

the

the staff employed immediately prior to the outbreak of War.

The number of Engineering and Clerical Staff who have lost their lives whilst on Active Service is I regret to say 942.

In November 1918 the question of demobilisation came under consideration and a very considerable amount of correspondence has, up to now, been involved in dealing with the arrangements for the early release from the Army of Departmental officers and men. Up to the 28th March 1919, 4654 of this Department's men have been demobilised from the Army, see Appendix M.

The numbers of staff of different grades actually employed at 31st March, 1916, 1917, 1918 and 1919 are given in Appendix N.

#### ECONOMY IN CLERICAL WORK.

80. With a view to releasing as many men as possible close attention was given to the possibilities of reducing clerical work to a minimum and considerable economies have been effected without involving undue risk. For example in connection with the preparation of Works Estimates simpler methods were adopted as regards the recording of spare wires of light gauge, the calculation of the value of displaced plant, the allocation of expenditure, and the determination of the figure for direct maintenance wages and labour. It was also arranged to discontinue the preparation of a number of returns and progress reports and to prepare less frequently other more essential returns. Certain checks of tools and stores were also made at less frequent intervals.

Notwithstanding the difficulties arising from the depletion of staff it has been possible to maintain a satisfactory degree of efficiency. It may perhaps be instanced that in connection with the District Monthly

Accounts the total delay in submitting the accounts in all Districts amounted during 1918 to only 47 days as compared with a delay of 77 days in 1917, 99 in 1916, 122 in 1915, and 492 in 1914. During the War period 4 Districts rendered all accounts without delay and during the Year 1918 nine Districts rendered all accounts without delay.

#### MAPS AND PLANS.

81. Much work has been involved in the preparation of maps, plans, charts, etc. giving detailed information of the Department's lines and illustrating special circuit arrangements for the War Office and Admiralty and a schedule of the principal items is given in Appendix C.

#### INSTRUCTION OF SIGNALLERS FOR NEW ARMIES BY P.O. INSTRUCTORS.

82. Following the formation of the new Armies and the necessity for securing large bodies of trained signallers, the Military Authorities requested the Post Office to provide instructors for training the men in signalling and technical work connected therewith. A detailed training syllabus was drawn up and the necessary sets of demonstration apparatus and training equipment were also supplied. The number of instructors varied throughout the period, and for a considerable time remained at the maximum figure of 43. The number of instructor weeks of service rendered during the whole period was 5050, and the approximate number of men to whom tuition was given was 60,000. The bulk of the men were trained for service in the R.F.A. and R.C.A. units.

Special courses of instruction were also provided for Officers and selected N.C.O.'s and men in the working of special types of apparatus, e.g.

Fullerphones

Fullerphones and Wireless Sets.

83. Lighting has been installed in the following buildings for Military and Naval purposes:-

ELECTRIC LIGHT  
AND POWER WORK.

Regents Park (Army Post Office)  
do. (Army Service Corps)  
Mount Pleasant (Australian Army Post Office)  
St. Pancras Station do.  
Money Order Office - additional premises  
Savings Bank do.  
Charterhouse Exchange.  
Tidworth P.O.  
Bulford P.O.  
Aldershot P.O.  
Invergordon P.O.

In addition, lighting restrictions have involved a considerable amount of work in the screening of lights both in London and the Provinces.

Two pneumatic tubes, each about half a mile long and complete with power plant, were installed in February 1917 between the Admiralty and the Ministry of Shipping in St. James Park. In July 1917 two pneumatic tubes each about 600 yards long, complete with power plant, were also provided between the Admiralty and the Shipping Controller's Department in Great George Street. A system of house tubes was also installed at Great George Street in conjunction with the main tubes.

Ten letter stamping machines have been installed in Army and Naval Post Offices and a number have also been supplied to Offices in proximity to camps and military establishments.

DAMAGE

DAMAGE TO  
ENGINEERING PLANT  
BY ENEMY ACTION.

84. On 73 occasions, raids by enemy aircraft caused damage to this Department's plant, the first raid causing such damage being that of 19th January, 1915.

The raid which caused the most extensive damage was that of 7TH JULY 1917, when bombs hit the South East corner of G.P.O. West building at 10.33 a.m.

A considerable portion of the balustrade running round the roof of the building was blown off and large masses of masonry fell into Newgate Street and St. Martin's le Grand. Happily, the screen of expanded metal provided by me (see Section 76) over the area surrounding the building proved sufficiently substantial to prevent serious damage to the Test Room in the basement. Owing to the width of the area at the East end of the South area, some of the masses of masonry fell on the screen but only two pieces actually penetrated it. Other pieces fell upon the parapet surrounding the area, fracturing it and dispersing the fragments upon the screen.

One block of stone measuring about 5 ft x 20" x 7½" fell through one of the glass roof lights into the Test Room but did no material damage. Another block fell through the screen and roof close to the area parapet and came to rest on the lead covered cables running along the area wall but not with sufficient force to fracture the lead sheathing. The fall of a third block was arrested by the screen and the block was brought to rest over the lead covered cables.

Unfortunately, the workshop on the roof was destroyed and about 100 sets of telegraph apparatus in the Central Telegraph Office were destroyed or

rendered

rendered inoperative by the explosion, fire and water. Owing however to the zeal and energy displayed by my staff communication was re-established with every Office the same evening.

As an expedient, the School in the C.T.O. was converted partly into a substitute workshop and partly into a substitute telegraph office.

Fortunately, no member of the Engineering or Operating Staff was injured; but, as is known, one sentry was killed outright and one died from wounds subsequently.

The total cost of reinstating the Engineering plant was approximately £5317.

A gas explosion and fire occurred in a subway under Piccadilly Circus as a result of the Zeppelin raid of 19TH OCTOBER 1917 causing the breakdown of several main cables, belonging to the Department. Over 2000 Subscribers' circuits and 400 Junction circuits were interrupted and to restore communication entirely it was necessary to make no fewer than 19,824 wire joints. All the circuits were either temporarily or permanently restored by the 28th of the same month.

The cost of repairing damage done by air-raids was as follows:-

In London, consequent upon raid of 7.7.17	£25752
" " " " all other raids	£3327
" Provinces	£1575
	<hr/>
Total	£10654
	-----

The cost of repairing the damage to Engineering plant caused by bombardment from the sea amounted to £530.

HIGH

HIGH SPEED  
AND PRINTING  
TELEGRAPHS

38. High speed apparatus has been introduced as extensively as possible into the London and principal provincial offices to facilitate the release of male telegraphists and to render ordinary telegraph apparatus available for the Expeditionary Forces. At the outbreak of War only 5 Inland circuits (representing 40 channels) were equipped with Multiplex Printing Apparatus but at the present time 25 circuits (representing 194 channels) are so equipped. The Creed apparatus at present in use comprises 49 Receivers and 39 Printers as compared with 17 Receivers and 8 Printers in July 1914.

Assistance was given to the French Administration by the installation of a Baudot repeater at Dieppe in February 1917. This enabled a triple duplex Baudot circuit to be worked via the Beachy Head - Dieppe cable between London and Paris and proved so successful that at the request of the French Administration a second line was similarly equipped and brought into use in August 1917. The original repeater was installed by one of my Headquarters Engineers and another of my officers supervised the working of the repeaters for several months.

In view of the interruptions to the French land lines via Amiens last spring, arrangements were made to increase the capacity of the more southerly Anglo-French lines by fitting repeaters at Havre. Three repeaters were accordingly despatched at the end of March, together with three officers to instal them and to supervise their working. Triple Baudot duplex was thus rendered possible between London and Paris on the Beachy Head -

Havre



Havre route. At the same time a repeater was also sent to Boulogne in order that Baudot duplex working might be introduced on the Boulogne route should the necessity arise.

During the War Hughes telegraph printing instruments have been supplied to the following Administrations and Companies:-

France (Civil) 50; France (Army) 12; Russia, 38; Greece, 5; Eastern Telegraph Company, 8; Direct Spanish Telegraph Company, 1; total 112.

Assistance has been given to a number of Cable Companies in the supply of other apparatus, including repeaters.

80. The application to working conditions of the Telephone Repeater, the progress with the development of which is described later in this Report, has been of great value in the maintenance of War Communications. For example, on the occasion of the Irish Rebellion, which coincided with the period of breakdown caused by the snow storm of March 1916 and when telephonic communication between London and Dublin was only possible by indirect circuits, a special direct circuit was formed and worked by means of a telephone repeater installed at Liverpool. At the same time other important internal War telephone communications were being maintained by the use of telephone repeaters.

TELEPHONE  
REPEATERS

In September 1917, The Director of Army Signals in France sought advice as to the use of valve amplifiers on certain of the long distance telephone lines worked by the British Army. A special portable form of

telephone

telephone repeater using the valve amplifier was designed in this Office, a specification was drawn up, and an order for 10 repeater units placed. It is understood that these repeaters have been of very great value to the British Army in France.

The use of repeaters in connection with the Peace Conference circuits has already been referred to in Section 4 (xiv) (Dover-Sangatte No.2 Cable).

CONTINUOUSLY  
LOADED CABLES

87. The necessity for placing trunk lines underground in the neighbourhood of aerodromes during the War has caused special attention to be given to the important problem of producing a satisfactory substitute for short sections of long overhead lines. After considerable research a practicable form of continuously loaded cable has been designed which has given very satisfactory results and a considerable length has been manufactured. Coil loaded cables, of course, are not at all suitable in similar circumstances although cheaper in first cost than the continuously loaded cable. The latter type however offers many advantages over the former and under certain working conditions is more reliable and less subject to deterioration.

TELEPHONE  
CIRCUITS  
SUPERPOSED  
ON SINGLE  
CORE  
TELEGRAPH  
CABLES

88. In August 1915 the Admiralty desired the establishment of telephonic communication between the Vice Admiral of the Dover Patrol and his Commodore at Dunkerque. At that time the only communication between this country and Dunkerque was by means of the single core telegraph cable referred to in Section 4 (ii). A special form of Van Ryselberghe composite circuit

was devised and a telephone circuit was superposed on the submarine cable length. Signalling over the telephone circuit was provided by means of a special high frequency arrangement which did not interfere with the telegraphs.

A similar arrangement was also resorted to in September 1915 in connection with the provision of a telephone circuit between the Grand Fleet Base at Scapa Flow and the mainland. In this case a telephone circuit was superposed on a Wheatstone telegraph circuit between the ends of the submarine cable and extended from the mainland end at Dunnet Head to Thurso, a distance of 10 miles on an ordinary metallic loop.

89. In March 1916 the Admiralty requested the assistance of the Post Office in the provision of a system of telephonic communications between the R.N.A.S. Headquarters near Dunkerque and the various Aerodromes and certain other points in the neighbourhood. Accordingly I arranged for an experienced Engineer to proceed to Dunkerque, and the whole of the work was planned and carried out by him. Four Skilled Workmen of my staff were also sent over. Labour and stores were procured locally. Considerable difficulty was experienced through working under foreign conditions and in meeting the wishes of both the French Military and Civil Authorities but the whole of the work was completed by the middle of May to the entire satisfaction of the Admiralty. One of the party was enlisted on completion of the work as a Petty Officer Mechanic to look after the maintenance of the system.

SPECIAL  
ENGINEERING  
WORK AT  
DUNKERQUE

BREAKDOWN OF  
MARCH 1916.

90. Reference should perhaps be made in this Report to the storm of 27th and 28th March 1916 which had such a disastrous effect upon the Department's plant and seriously affected Naval and Military communications in this country. The direction of the gale, which was accompanied by heavy falls of snow and freezing rain, was from the North East and the area most seriously affected was a belt of country bounded on the North by a line from the Humber to Pembroke and on the South by a line from the Wash to the Bristol Channel. Every telegraph line crossing this belt in a more or less North to South direction was either blown down or badly damaged. Over 41,500 poles had to be re-erected which is equivalent to 1,400 miles of main pole line. More than 17,000 miles of copper wire had to be collected, melted down, and remanufactured. Obviously therefore the restoration would have been a Herculean task and would have taxed the resources of the Department to the utmost even if our full force of workmen had been available. To meet the emergency such experienced men as were available were drawn from all parts of the country to augment the staff in the storm-belt and the assistance of several thousand soldiers was also obtained.

Fortunately we had the new underground telephone cable between London and Liverpool (which as a result of pressure on my part had just been brought into use) and the underground telegraph cable to the North to fall back upon. The wires in these cables were extended on aerial lines to a number of towns in the Midlands and the North and in this way a complete severance of communication between London and the North was avoided.

The cost of repairing the damage caused by this storm amounted to at least £350,000.

Arrangements are now in hand for providing a direct underground service with the more important towns in the Eastern Midlands such as Northampton, Leicester and Nottingham.

91. The emergency created by the Sinn Fein Insurrection of Easter 1916 constituted a severe test of the Engineering Staff in Dublin. It will be remembered that the Post Office there was occupied by the rebel forces about noon on Monday, April 24th, and the staff evicted, thus interrupting telegraphic connection with the outside world and throwing the Trunk Exchange out of use. One of my Engineers at once proceeded to Amiens Street Station and opened communication by telegraph with London at 1 o'clock and so enabled the various Government Departments concerned to be notified. At the same time the Sectional Engineer got into communication with the Military Authorities and promptly obtained a Guard for the local Telephone Exchange which was situated at some distance from the Post Office. It was therefore possible to maintain telephonic communication between important centres in Dublin. The Superintending Engineer was able to keep in frequent communication with me concerning the state of affairs and I was able to arrange for large quantities of apparatus, wire, and cable to be promptly despatched to meet his needs.

Whilst the fighting was in progress, temporary Telegraph Offices were opened at Amiens Street, Broadstone and Kingsbridge Railway Stations.

DUBLIN  
DISTURBANCES,  
EASTER 1916.

Telegraphic communication for military and Official purposes between Great Britain and the most important places in Ireland was thereby restored and maintained throughout. Within a day or two a few trunk circuits were got through to other parts of Ireland and one to London.

It was decided on May 3rd to instal a new Central Telegraph Office in the Parcels Office at Amiens Street in order that the public services might be reopened. The construction of tables by the Board of Works was put in hand, apparatus was despatched from London and by means of continuous work the instrument room giving direct communication with over 80 towns was brought into use on May 9th, the day fixed by the Military for the restoration of public communication. The use of the temporary offices at Broadstone and Kingsbridge were then discontinued. The apparatus installed included Duplex Repeaters, Forked Repeaters, Duplex Wheatstone, Duplex and Simplex sets.

The unbounded loyalty and perseverance with which the Engineering staff in Dublin pursued their efforts were most praiseworthy and the Postmaster General expressed his appreciation of the self-sacrificing labours which had resulted in so promptly restoring communications.

COMMANDER-IN-  
CHIEF'S MOBILE  
HEADQUARTERS

92. A Railway train of ten coaches to serve as a Mobile Headquarters for the Commander-in-Chief in France was fully equipped in May 1917 with a telegraph office comprising one Wheatstone set and five Morse sets of apparatus. A telephone exchange for fifty lines was also installed and facilities provided for rapidly making  
and

and unmaking connection with external lines. One interesting feature in connection with this train was that the several coaches were so wired that their order in the train could be varied at will without disturbing the system of communication. I also devised a special cable-drum to be fitted under the floor of the coach which formed the instrument room, and by means of which the train could be speedily connected up to aerial lines terminating at poles specially erected in proximity to the Railway at a number of points.

A similar but smaller equipment was also fitted in a train specially constructed in the Summer of 1917 for the use of the Field Marshal in Command of Home Forces.

93. A special telephone system, for use between Basra and Bagdad, with a number of intermediate stations, was designed in the Summer of 1917 for the Director of telegraphs in India and specifications of the plant required were supplied. In connection with the scheme I arranged for the despatch to Mesopotamia of 300 tons of 500 lb. copper wire, 80,000 insulators, and 80,000 spindles.

MESOPOTAMIA  
TELEPHONES

94. Considerable assistance has been given to the Belgian Civil Authorities in connection with the supply of telephone and telegraph apparatus for the re-equipment of Belgium on the cessation of hostilities. I arranged in 1917 for the despatch to Havre, from our stocks, of over 5,000 subscribers' telephone sets, 1,500 switches, 500 switchboards,

ASSISTANCE TO  
BELGIAN  
ADMINISTRATION

1,750 bells, 4,000 receiver and switchboard cords, 3,500 protectors, and other telephone apparatus, together with 500 sets of sounders, keys, galvanometers, relays and condensers.

In addition a large amount of equipment has been supplied for the Belgian Army.

I arranged also for the employment in this Department of a considerable number of Belgians who were either unfit for the Army or exempt for special reasons.

U.S.A. ARMY  
COMMUNICATIONS

95. A number of requests were made from time to time to meet the needs of the U.S.A. Army authorities, following the establishment of camps in this country towards the end of 1917. Apparatus was fitted at the various camps to provide for the necessary local service and to give access to the general system. A telephone trunk between London, Winchester (Morn Hill), and Southampton, with a telegraph circuit superposed, was placed at the disposal of the U.S.A. authorities in December 1917, and a further telephone circuit to Morn Hill was provided in October 1918. A telephone circuit, with telegraph superposed was also handed over in July 1918 for U.S.A. use between London and Knotty Ash, Liverpool. (The Anglo-French service provided for American traffic has already been referred to in Section 4 (xi) (Cuckmere - Havre No.2 Cable.)

ADMIRALTY  
TRAFFIC  
CONTROL  
CIRCUIT  
CALEDONIAN  
CANAL

96. In connection with the Control of Traffic on the Caledonian Canal the Admiralty, at the end of 1917, requested the provision of telephonic facilities. The requirements were considered at a conference at the Admiralty and a scheme was prepared which provided all the necessary



necessary facilities by erecting a single pair of wires between Inverness and Fort William. Each of the numerous lochs, etc., upon the route was provided with specially designed selective signalling apparatus connected to the new circuit.

Switchboards constructed to provide local intercommunication facilities, and to enable any points to have communication with the long distance control circuit, were installed at the terminal stations.

97. A very comprehensive system of communication was established during the early and middle parts of 1918, in connection with the Anti-Submarine Stations on the Irish coasts. The lines placed at the disposal of the Seaplane authorities involved the provision of telephonic connections between Rathmullen (Lough Swilly), Londonderry, Larne, Belfast, Dublin, Waterford, Cork, Queenstown, Bantry and Castletown Bere, with a number of subsidiary connections. The service was made available by the withdrawal of a number of long distance circuits from public use, and by the erection of a considerable mileage of telephonic loop.

IRISH SEAPLANE  
STATION  
COMMUNICATION  
SYSTEM

The stations were also fully equipped with switchboards and telephone apparatus to provide the necessary local intercommunication facilities.

98. As a result of special duties imposed upon the Royal Irish Constabulary the existing telephonic facilities in Ireland were in many areas found to be inadequate, and a demand was made at the beginning of 1918 for a number of additional connections to the general system. The construction

ROYAL IRISH  
CONSTABULARY  
COMMUNICATION  
SYSTEM

of

of new lines was undertaken, and switchboards modified to meet the particular requirements were supplied and fitted.

VISITS TO  
FRANCE

99. I have already referred briefly in Section 4 (xii) (new Audrecelles cables), to the visit which I paid to G.H.Q., France, in March 1918 at the invitation of the Director of Army Signals. In addition to the subject therein referred to several other important matters were discussed with advantage, such as the improvement in transmission value of Anglo-French Military circuits, the merits and demerits of various types of apparatus, the disposal of line stores on the declaration of Peace, and Signal Service requirements as regards men skilled in permanent line work. Opportunity was also taken to inspect the Army system of communications.

In February of this year I again visited France and inspected

1. the methods adopted by the Army for obtaining balanced aerial trunk lines suitable for phantom working:
2. a vast quantity of telegraph and telephone material left by the Germans:
3. the systems of telephone through line repeaters and cord circuit repeaters adopted by the Army:
4. the telephone repeater equipment at Cologne which it was stated had enabled all German Army Headquarters to be kept in communication with Berlin.

With regard to 1. broadly speaking the Army adopted the straight wire system with various methods of spaced crossing points as distinct from our standard method of revolving the wires. The conclusion arrived at was that the Army system was admirably suited for war service conditions but would probably not be more suitable for  
aerial

aerial line conditions in this country than the "revolving" system. A comparison of fault records on three London-Paris circuits which are on aerial lines in this country and in France supports that conclusion.

As regards 2. the German line material was generally of "War finish" and unsuitable for use in this country. The apparatus was on the whole well made and finished but gave evidence of the shortage of copper in Germany. A number of samples of apparatus were selected with a view to studying interesting points concerning manufacture.

The telephone repeaters referred to under 3 are modifications of arrangements recommended by me. They give moderate transmission improvements and appear to be very stable when line conditions are favourable.

The system of repeater working in Cologne is well known to us and is considered inferior to our standard system but the German thermionic amplifier presented a marked difference in design and samples were brought back for investigation.

I should like to place on record in this Report my appreciation of the courtesy and facilities accorded to me by Major General Fowler, Col. E. V. Turner, and Lt.Col. Edgeworth on the occasion of my visits to France.

100. For services rendered in connection with the War His Majesty the King has been graciously pleased

HONOURS

pleased to appoint six of my Engineers to be Officers of the Order of the British Empire and eight to be Members of that Order. In addition the medal of the Order has been awarded to 58 members of the minor grades of my staff in recognition of meritorious conduct in circumstances of danger. It should perhaps be mentioned that two of the Officers, three of the Members, and twenty of the Medallists belonged to the Submarine Cable staff.

B. ENGINEERING WORK, NOT DIRECTLY CONNECTED WITH THE WAR, CARRIED OUT DURING THE WAR PERIOD

Reports on the general work of this Department have been submitted annually to the Secretary during the war period but the following is a resume of the salient features of the Engineering Department's non-war work.

DEVELOPMENT

EXPENDITURE  
ON ENGINEERING  
PROGRAMMES

101. Particulars of the authorised and ascertained expenditure under the various headings of the Annual Programmes are given in Appendix Q.

MAIN LINES

102. Details of the main underground works completed since 31/3/1914 are given in Appendix R and Appendices S and T illustrate in diagrammatic form the position respecting main telegraph and telephone cables at 31/3/1914 and 31/3/1919.

The quantities of wire and poles erected in connection with the provision of overhead public trunk circuits

circuits during the past five years were as follows:-

<u>Year</u>	<u>Miles of wire</u>	<u>Number of poles</u>
1914-15	22,040	17,200
1915-16	12,000	7,100
1916-17	844	353
1917-18	763	543
1918-19	315	218

The following lengths of new pole lines have been built to relieve congestion on existing main trunk routes:-

Ware to Sleaford	87 miles
Hastings to Lewes	24 "
Sudbury to Needham Market	18 "
Reading to Newbury	17 "
Canterbury to Folkestone	16 "
Durham to Bishop Auckland	10 "

A list of the main underground works included in the 1919-20 Trunk Telephone Programme is given in Appendix U.

103. Excluding work carried out under the Superintending Engineers' authority, the total Local Line plant provided during the period 1st April 1914 to 31st March 1919 was 1,339 miles of single duct, 2,120 miles of cable, 25,333 poles, and 13,484 miles of open wire. Details are given in Appendix V.

#### LOCAL LINES

Since the signing of the Armistice on November 11th 1918, active steps have been taken to expedite the preparation of schemes for the provision of line plant in the London Telephone Area and Provincial Exchange Area, where difficulty is being experienced in joining up Subscribers. Up to the end of the 31st March a number of schemes have been approved and authorized, the largest of which are

as follows:-

Eccles Underground scheme ..	£24,000
South Dalston Underground ..	£14,280
Malvern & Colwell Underground	£13,614
Mayfair Development .. ..	£11,842
Yarmouth Underground scheme	£11,118
Dewsbury Underground .. ..	£9,696
Kingston - Portsmouth Road..	£5,612
Felixstowe Underground ..	£5,348
Failsworth Underground ..	£5,177
Lincoln Underground ..	£5,000

#### WAYLEAVES

#### CROSSINGS OVER RAILWAYS

104. I am happy to report that I concluded an important Agreement in March 1915 with practically the whole of the Railway Companies as regards crossings over railways. Trouble had been experienced with the L. & N. W. R. Co. and a certain number of stipulations were prepared which that Company agreed to and which were subsequently placed before other Railway Companies. Finally, the matter came before a Conference (in London) of Railway Telegraph Engineers, which I attended, and at which all opposition was withdrawn and a general agreement arrived at.

#### PROTECTION FROM POWER CIRCUITS

105. Instructions were issued in May, 1914, dealing with an important modification regarding guard wires for Electric Light and Power circuits. The use of current-carrying earthed wires (neutral wires) as guard wires, was agreed with the Board of Trade. The new guarding arrangements should result in greater efficiency at a less cost to undertakers.

In November, 1914, the concession to Tramway Undertakers under which the Post Office bears half

the

the cost of guard wires when the Post Office is "second-comer" was extended to Electric Light and Power undertakers.

A fatal accident occurred in July, 1914, on a "joint" pole near Leeds. Investigation showed that the officer had accidentally raised himself above the "earthed" platform which had been erected as a screen between the power wires and the telegraphs, and had approached within striking distance of the power wires.

The general question as to the use of joint poles has been thoroughly investigated and correspondence with Power Companies regarding existing "joint poles" both on road lines and on Railways has been entered into with a view to the placing of either the Department's or the Power wires underground at the danger points. No new "joint" poles are now being agreed to.

For a new Extra High Tension crossing over a Telephone Trunk line in South Wales where Underground for the power line presented many difficulties a specially designed guarding arrangement was agreed to in 1915 in order that the power circuit might be erected overhead. The guarding arrangement consists of a substantial steel net erected between the Telephone Trunk line and the power wires. The net is carried on steel poles independent of the power poles and is earthed direct to the ground and connected to the earth wire of the power system. The net will prevent a broken wire from coming into contact with

with the telephone trunks. To minimise the risk of a breakage of the power conductors the crossing span is limited to 40 yards. The power poles are of steel, each capable of acting as a terminal in the event of a collapse of the power line on either side.

Considerable trouble has been experienced in enforcing the protective requirements of the Board of Trade Regulations (prescribed under Section IV of the Electric Lighting Acts, 1888), and as the Board of Trade have not been prepared to take any legal action in any case an amendment to the Regulations has been agreed upon which will enable the Department to take Court proceedings where necessary in order to obtain adequate guarding arrangements.

Serious inductive interference with important trunk circuits occurred in 1915 at Dumbarton and Halifax, which was traced in each case to the Rotary Converters used for supplying current to the Tramway systems. The manufacturers of the Rotary Converters were successful in modifying the machines thereby reducing the disturbing pulsating power current. The interference with the trunks is now negligible.

Similar interference was experienced when the London and South Western Railway electrification was put into operation. The Company was informed of the trouble and its cause. As their Engineers, however, did not agree, it was necessary to apply for an injunction to restrain the Company from  
working



working the line until the interference was remedied. After the Court proceedings consultations took place and finally it was demonstrated that the cause was as stated by the Department. The Rotary Converters were modified as in the previous cases with similar results and the application for an injunction was then withdrawn. The Company were, however, warned that in the event of an extension of the electric working along the main line interference would be likely to result to the telephone trunks unless the design of the Rotary Converters was much further improved or unless the fourth rail or insulated system was adopted instead of using the running rails for the return current. This warning was given because the electrification of the line was carried out under the general powers of the Company and without notice to the Department. Further extension of the electrical working may be carried out also without notice.

Electrolytic action was the cause of the breakdown of several telephone cables in Birkenhead in 1915. The damage was traced to a section of route about one quarter mile in length where large leakage currents from the Tramway system were carried by the Department's cables. The Corporation had borne the expense of replacing the telephone cables, and the Department has pressed for the leakage currents to be reduced. The Corporation, after taking expert advice upon the subject, agreed

some

some months later to the provision of additional negative return cables which was a condition precedent to the Department earthing the lead sheathing of its cables at certain points.

Corrosion of the lead sheathing of cables has come to light at several other places caused, in most cases apparently, by electrolytic action due to stray currents, but the evidence was not always sufficient to justify claims for the recovery of the cost of repair from Power Undertakers. In one case where the evidence seemed conclusive a claim was made against the Blackpool and Fleetwood Tram-road Company, but the Company refused to pay on the ground that the Board of Trade Regulations had been observed. On reference to the County Court a decision adverse to the Postmaster General was given from which it is intended to appeal, as the Department is advised that the Postmaster General's claim is valid if the Post Office plant can be proved to have been damaged by the working of the Tramway System, i.e. that the Postmaster General's protective clause in the Tramway Act, is sufficient in itself to establish the claim. Great importance is attached to the case, as Tramway Undertakers generally are interested.

#### TELEGRAPHS.

##### BAUDOT DUPLEX.

106. During the period 1914-1919 the most noticeable feature as regards the development of telegraphic systems was the extension of the use of Baudot Duplex. The large number of additional circuits worked by this method enabled arrangements to be made to release Morse staff required for Military purposes.

The principal towns affected were as follows:-

London - Birmingham	Sextuple Duplex
London - Liverpool	Quintuple Duplex

London

r.

London was equipped with quadruple Duplex to work to the following towns:-

Glasgow	Grineby
Birmingham	Leeds
Southampton	Plymouth
Newcastle	Sheffield
Hull	Nottingham
Cardiff	<del>Warrington</del>
Manchester(2 circuits)	<del>Manchester</del>
Edinburgh	

Quadruple Duplex was also worked between Liverpool and Manchester and between Glasgow and Edinburgh.

As stated in Section 85 Triple Duplex was established between London and Paris working on two circuits via Havre, and sometimes on the other routes through Dieppe and Boulogne.

In the later installations the weight driven distributors were replaced by electrical drive on the phonic wheel principal, and have so far proved very satisfactory.

107. No special development has occurred during the period with this system owing to the difficulty of manufacture, but a number of Baudot receivers were altered to run at a speed of 40 words per minute and have given excellent results. MURRAY SYSTEM.

108. The use of this system has not been extended but very good results have been obtained by it, and a noticeable improvement has been introduced by a Post Office official in advancing the paper band so as to save considerable line time. It is known that a type bar printer is in use by the Western Union which will probably prove superior to the type wheel now in use in the set used by the Post Office. WESTERN  
ELECTRIC  
MULTIPLEX.

Wheatstone

WHEATSTONE  
AUTOMATIC  
SYSTEM.

109. There has been no development in the use of this system beyond the introduction of a vibrating relay known as the "Post Office Standard Relay G" referred to in Section 112. The use of this relay enabled a speed of 200 words to be obtained on an underground loop circuit of 40 lbs copper wire over a distance of 190 miles. The use of this relay will enable underground cables to be worked with much smaller cable wire, not only for Wheatstone but for the Duplex Multiplex Systems.

A large number of Wheatstone instruments are now driven by electric motor, the alteration having been carried out during 1917-18.

CREED SYSTEM.

110. Twenty-three additional receiving perforators and 26 Creed printers were purchased in 1914 and a further supply of 10 receivers and 13 printers loaned by the Creed Company were also purchased. Improvements by Post Office officials enabled three slips to be prepared by one machine, both as regards the perforator and the printer. This improvement is particularly valuable in connection with press work.

KEYBOARD  
PERFORATORS.

111. Keyboard perforators of the Gall and Kleinschmitt type have been brought into considerable use during this period owing to the need of expert operators being required to be released from Post Office service for Army purposes.

POST OFFICE  
STANDARD  
RELAY G.

112. This instrument based on the Gulstad principle has been brought into use because of the inability to obtain Gulstad relays from the Danish Government who have prohibited the export of these instruments during the war. The adapted instrument is in some respects superior for Post Office purposes to the Danish form of instrument, and it has been found possible by using this G relay to dispense with the use of a repeater.

113. Owing to the high price of Dry Cells due to heavy demands by the War Office and Admiralty of this particular type, the Post Office largely extended the use of small secondary cells and the Leclanche type of wet cell, the most noticeable case being that of the C.T.O. where some five thousand dry cells were in use and are being replaced.

In this connection, power has been supplied to newspaper offices so as to relieve them of the trouble of maintaining batteries.

114. Installations were completed at G.P.O. South (Carter Lane); Queen Victoria Street in the offices of the Controller L.T.S.; G.P.O. West (Auxiliary Clear Out System); Stores Department, Fordrough Lane, Birmingham; Head Post Office, Birmingham; Head Post Office, Leeds; Head Post Office, Cardiff; as well as at a number of smaller Post Offices.

FIRE ALARM  
CIRCUITS IN  
POST OFFICE  
BUILDINGS.

115. War conditions prevented the large extension of this system that would otherwise have been carried out, but two 60-line and one 30-line lamp signalling concentrators were brought into use.

TELEGRAPH  
CONCENTRATOR  
SWITCHBOARDS.

116. A large number of these were converted from telegraph to telephone working, necessitating the provision of special phonogram equipment in respect both of lines and of switching apparatus at many offices.

MINOR  
TELEGRAPH  
CIRCUITS.

117. (1) Telepost System. This high speed system was again tried but the results were not sufficiently good enough to warrant a trial under working conditions.

EXPERIMENTAL  
WORK.

(ii) Kotyra Keyboard Perforator. The improved installation was unsatisfactory on account of its delicate mechanism which was not sufficiently robust to stand the necessary wear and tear.

- (iii) Pala Receiving Perforator. This instrument was tested and found to be inferior to the Crsed Receiving Perforator.
- (iv) American Telegraph Typewriter Company's Printing System. The speed of this apparatus is 40 words per minute which was too low to warrant its use on long circuits and the cost was too great for short lines.
- (v) Balsara Telegraph System. This instrument is based on the Hughes Printing Telegraph and gave a speed of 40 words per minute. This speed is also too low for long circuits and the purchase price too expensive for short lines.
- (vi) National Telewriter Company. This new printer has been examined and approved for trial on a public circuit.

COMMITTEE ON  
HIGH SPEED  
TELEGRAPHY.

118. The Committee (consisting of <sup>Captain Norton (now Lord Rethelstan) Am! P.M.A.</sup> ~~Lord Stanley~~, Chairman, Sir John Gavey, Sir William Slingo, Messrs Lee, Mordey, Ogilvie and Walkley) appointed in January 1914 "to enquire into SYSTEMS OF HIGH-SPEED TELEGRAPHY" submitted their report to the Postmaster-General on the 19th January 1916.

RADIO - TELEGRAPHY.

IMPERIAL WIRE-  
LESS SCHEME.

119. Following the cancellation of the contract for the Imperial Wireless Scheme, on the understanding that the Post Office pay the Marconi Company out of pocket expenses in connection therewith, assistance has been rendered in checking the amount of Stores used and in stock, and approximate estimates of the value of such material chargeable to the Post Office have been made. The checking of the quantities of material which the  
Company

Company were allowed to draw from the stock of materials held for this scheme, and of the relative accounts, has also been carried out by this Department.

In 1918 evidence was prepared in connection with the Company's Petition of Right for damages consequent upon the cancellation of the contract but the decision of the Crown not to resist the Petition obviated the necessity of furnishing this evidence. Evidence has also been prepared in connection with the question of damages now before the Arbitrator appointed to assess the amount, if any, due to the Company. Many consultations have been held from time to time with Counsel and decisions arrived at in connection with the defence. In this connection information was obtained by visits in September 1918 to the Nantes and Eiffel Tower Wireless Stations, which work on the Continuous Wave arc systems, and to the Marconi Company's Station at Carnarvon. The ninety-eight patents scheduled by the Company have been examined and reported on, which work has necessitated close co-operation between my Officers and Counsel and the Consulting Engineer retained by the Department.

120. Evidence was prepared for, and many consultations held with Counsel and other opponents to the petition of the Marconi Company for an extension of the Fleming Patent 24850/04 for valves, and during the hearing of the case in December 1918 Counsel was advised by this Department's Officers on various technical matters. The petition was dismissed with costs.

FLEMING PATENT  
& MARCONI CO.

121. Though the ship and shore stations (CULLERCOATS, NORTH FORELAND, St. CATHERINES, LANDE END, FISGUARD, SEAFORTH, MALIN HEAD, VALENCIA, & CROOKHAVEN) were under the control of the Admiralty during the War, the whole of the maintenance has been, and is still, carried out by this Department.

SHIP & SHORE  
STATIONS.

The

The island-communication stations LOCHBOISDALE and TOBERMORY and the stand-by stations at GUERNSEY, BOLT HEAD, HUNSTANTON and DOUGLAS were also taken over by the Admiralty but maintained by the Department.

Various alterations have been carried out at the NORTH FORBLAND station during the past four years. This station has also been used for Dutch commercial traffic and early in 1919, when the station was handed back to the Post Office, communication was established with Antwerp on a wave length of 1200 metres.

STONEHAVEN &  
CULLERSOATS  
HIGH SPEED  
COMMUNICATION.

122. The contracts for the erection and equipment of long distance and high speed stations at Stonehaven and Cullercoats were placed with the Marconi Company.

The Stonehaven station was taken over by the Department in August 1916 when satisfactory tests were made with Christiania and Stavanger and subsequently the Admiralty took over the station. Since its retransfer to the Department in February 1919 satisfactory communication with Iceland and Christiania has been obtained and since March Stonehaven has maintained communication with the Continent to relieve congestion on the Dutch Gables.

War conditions caused delay in the work of installing the plant at Cullercoats, and in order to relieve the Contractors completion was undertaken by the Department. This equipment, which replaces that formerly installed there, has been in use since July 1917.

LEAFIELD  
WIRELESS  
STATION.

123. Since the retransfer to the Department last March of the Leafield station, which has been used by the Admiralty for interception work since the early days of the War, specially designed receiving apparatus has been installed in readiness for the opening of communication between this station (in conjunction with Horsea) and Egypt.



124. In order to establish communication with Douglas during the interruption to the St. Bees - Isle of Man cable in March 1919 a wireless station was established at Heysham, the Seaforth Station which normally serves as the Mainland Communication Station being in the hands of the Admiralty. A second station was also installed at Fleetwood and was worked for a short period.

WIRELESS  
COMMUNICATION  
WITH ISLE OF  
MAN DURING  
STOPPAGE OF  
CABLE.

125. Much useful design, testing, etc. work has been carried out at the wireless Laboratory in G.P.O. West. The following items may be mentioned:-

WIRELESS  
LABORATORY.

A new condenser bank for use with a standard wave meter designed and constructed.

A new type of high frequency ammeter designed,

A remote observation high frequency ammeter for use at stations designed,

Trials of porcelain as a substitute for ebonite in spark circuit apparatus carried out.

A musical spark transmitting apparatus installed.

A standard wireless apparatus testing set for measuring capacity inductance and high frequency characteristics of circuits installed, together with wave length, standard ammeter, voltmeter, wattmeter, and crystal telephone testing sets. These sets which were mainly designed and made in the Laboratory will greatly facilitate experimental work contemplated in the future. Permission has been granted to one of my Officers to patent the high frequency characteristics measuring set referred to.

126. A calling device for short range sets was designed and fitted as an auxiliary to the Skerries-Conlyn induction system and continues to give satisfaction.

EXPERIMENTAL  
WORK.

Short range installation sets of new type have been tried and proved satisfactory. Apparatus of the old type has since been replaced by that of the new pattern at all short

short range installations.

Experiments with directive Aerials at stations erected on Wimbledon Common and at Wandsworth were carried out and showed that at present directive aeriaks do not offer any advantages for short range installations.

Investigation has also been made with regard to the best type of circuit for use with magnifying valves, and as a result, the valve sets installed at Valencia, Stonehaven, and Caister, were designed and made in the Department's Wireless Laboratory. The Marconi Company were formerly the sole suppliers of these sets. Moreover the Departmental sets are of a superior type and meet the need better than would the Marconi apparatus.

The direct visual recording on morse tape of wireless signals has been effected.

A promising system of using thermionic valves for the magnification of submarine cable signals has been evolved by my Wireless Staff and the apparatus is now under test. The system has also proved useful in the magnification of wireless signals and a similar set of apparatus has been installed at the Leafield Station in connection with wireless communication with Egypt. The interests of the Department have been safeguarded by provisional patent protection.

TELEPHONES.

AUTOMATIC  
TELEPHONES.

127. New Automatic Exchanges have been opened  
during the period of the War at :-

Exchange	Capacity	
	Present	Ultimate
Accrington *	860 lines	1500 lines
Blackburn *	2400 "	4000 "
Chepstow	65 "	100 "
Darlington	820 "	3800 "
Dudley	520 "	1600 "
Grimsby	1376 "	4000 "
Leeds	3800 "	15000 "
Newport (Mon.)	2060 "	3500 "
Paisley	1260 "	2150 "
Portsmouth	5200 "	7000 "
Paddington Automatic Traffic Distributor	1000 "	

\* Multi office working between Accrington and Blackburn subscribers introduced with satisfactory results.

The following improvements in connection with Automatic Exchange equipments have been introduced and adopted as standard.

Dialling direct from distant Trunk and Local Exchanges, with standard supervisory signals.

Providing a "number unobtainable" tone to calling subscribers when Dead Numbers and Dead Levels are dialled.

Enabling Flat Rate Two party line Subscribers lines to operate similar to ordinary Automatic Subscribers.

Enabling Coin Box Subscribers circuits to be operated as Automatic Subscribers.

Provision

ALABAMA  
COMMUNICATIONS

Provision of a meter associated with Two Party Line Subscribers Circuits, to enable measured rate Service lines to be operated Automatically.

Transmission on Calls completed by manual operators in the Automatic Exchange by providing talking current for the called Subscriber direct from operators cord circuit.

Numbering the Automatic Exchange Switching plant to enable calls to be traced forwards or backwards, thus improving maintenance conditions.

Enabling the trunking scheme in Automatic Exchanges to be varied to meet the traffic requirements without modification to permanent wiring.

Provision of a Permanent Glow Signal on 1st Selectors, to enable line faults to be removed quickly from the Automatic plant.

In connection with the installation and maintenance of Automatic Exchange plant, the following technical information has been prepared and issued for the guidance of the local engineering staff.

35 Instructions for Testing Out the Automatic Exchange plant during the period of installation.

44 Descriptions of Circuit operation of the various Automatic Exchange Systems.

Instruction outlining the type of automatic telephone apparatus to be used on Subscribers premises for all installations including Private Branch Exchange Switchboards for the various Automatic Exchange Systems with details of alterations to be adopted for working to the existing manual Exchange during the transition period.

300 Standard Diagrams of Circuit arrangement for the various Automatic Exchange Systems issued.

Instruction regarding the maintenance and fault procedure in Automatic Exchanges.

Circuit arrangements have been developed for introduction in future Exchanges to enable non fee junction calls to be registered by the Manual operator after completion of conversation, thus saving the preparation of a ticket record.

The subject

The subject of the introduction of Automatic Exchange working in the London area has received close consideration and the various points in connection therewith are at present being dealt with by a Committee composed of Traffic and Engineering representatives.

NEW MANUAL  
C.B. EXCHANGES

128. Particulars of the various new C.B. Exchanges and Exchange extensions dealt with during the war period are shown in Appendix W.

NEW SMALL  
EXCHANGES.

129. Apart from the installation of new exchange equipment undertaken by contractors on behalf of the Department, approximately 450 new equipments have been installed by the Department's staff. In a large number of these cases, special call office facilities were also arranged for.

EXCHANGE  
TRANSFERS.

130. Small exchange transfers, usually necessitating the provision of entirely new equipment, have been arranged for in approximately 110 cases. The whole of the work in these instances has been undertaken by the Department's staff.

TRUNK & LOCAL  
AMALGAMATION

131. In 69 cases trunk exchanges have been closed and the circuits transferred to the local exchange, thus amalgamating the trunk and local services.

TRUNKS WORKED  
AS JUNCTIONS.

132. In addition to the considerable number of circuits outlined in the foregoing, a very large number of trunk circuits have been transferred to the local

exchanges

exchanges in towns where trunk exchanges are still maintained. The transfer has entailed a conversion in the method of working from trunk to junction signalling principles. To deal with these alterations, means had to be devised for dealing with lines up to a length of 60 miles, and this entailed the design of a number of special circuit arrangements and the preparation and issue of a large number of diagrams and letter press instructions.

133. A lamp signalling multiple switchboard arranged on C.B.S. principles and worked from primary batteries has been developed and stocks obtained. Seven exchanges comprising in the aggregate 25 operators' positions have been provided with this type of equipment, the installation work being undertaken in all cases by the Department's local staff. The operation of the board, both from a Traffic and Engineering standpoint, has been under continuous observation since the first installation was completed and appears to be giving general satisfaction.

NEW PATTERN  
MULTIPLE  
SWITCHBOARD.

134. A detailed study was undertaken in connection with the requirements of private branch exchange working, and a series of standard boards have been designed and manufactured: a large number of the boards have already been fitted and have given satisfactory results. Boards needed to accommodate less than 10 lines are of the cordless type and are fitted with positive audible clearing signals. Where accommodation from 10 to 25 lines is required, a double cord floor board has been adopted: in this case also positive audible clearing signals have been provided. The third board of the

C.B.PRIVATE  
BRANCH  
EXCHANGES.

series

series has a capacity of 65 lines and although it has been found necessary to retain the negative signals considerable improvement has been made in the speech transmission on the exchange lines by a re-design of the circuits.

A detailed technical instruction, comprising all the necessary engineering data and diagrams, has been prepared and issued to all officers concerned with the installation of C.B. Private Branch Exchanges.

The method of dealing with the installation of C.B. ~~Multiple~~ <sup>Multiple</sup> Private Branch Exchanges has been standardised and a detailed Instruction has been prepared and issued.

TELEPHONE  
TELEGRAM AND  
PHONOGRAM  
ARRANGEMENTS

135. A considerable provision of circuits has been arranged to facilitate the disposal of telegrams by telephone. Unfortunately the work of standardising phonogram arrangements which was being dealt with by a Committee were incomplete when the exigencies of the service brought about by war conditions resulted in the Committee being dissolved. Arrangements have, however, been made for the provision of a number of equipments arranged on an ancillary basis. Two systems have been designed: one a common battery lamp signalling type, and the other arranged for primary battery indicator signalling working. A number of diagrams and instructions have been prepared in connection with this development for issue to the staff concerned.

136. A number of Operating Schools fully equipped with instruction apparatus have been opened in London and the Provinces.

OPERATING  
SCHOOLS.

137. The standardisation of coin collecting boxes has been arranged. A new type of box has been designed with a view to minimising the loss sustained by theft. Special combinations of locks have been provided so as to avoid the necessity for using locks and keys of similar pattern in adjacent collectors' areas.

COIN COLLECT-  
ING BOXES.

138. Steps have been taken to co-ordinate the requirements for the control of call office circuits by counter clerks and attendants. A number of special boards for assembly on a unit basis have been designed and made available for use. A special set of diagrams with the necessary letter press instruction has also been prepared and will be available for issue at an early date.

CALL OFFICE  
SWITCHBOARDS

139. The standardisation of the circuit arrangements dealing with power plant at C.B. exchanges has been completed and the necessary diagrams and instructions have been prepared.

C.B.EXCHANGE  
POWER  
CIRCUIT.

140. A considerable amount of replating work has been undertaken. Instructions have been issued in all cases of threatened failure of batteries detailing special tests to be made, and a study of the result secured has enabled the exact condition of the plant to be determined.

SECONDARY  
CELLS.

Comprehensive instructions based on investigations which have been in progress for a considerable period,

and having



and having for their object the more satisfactory maintenance of secondary cell plant, have been drawn up and issued to all officers concerned.

The specification for large secondary cells has been materially stiffened with advantage to the Department, and the full requirements have been met in a number of cases where contracts have been placed.

A special investigation was made in connection with the requirements to be met in Departmental practice for accumulators up to a capacity of 40 ampero hours. It has been possible to standardise the whole of the parts comprising accumulators of various capacities up to a maximum of 40 ampere hours, and considerable numbers of the new pattern of cell have been obtained and brought into service. Under the new scheme, there is complete interchangeability of parts which avoids the necessity for approaching different contractors for replacement parts for cells which were originally provided by them.

POWER RINGING  
AT SMALL  
EXCHANGES.

141. As an alternative to the gas engine and motor generator ringers, a new type of ringing vibrator has been successfully introduced. Very considerable economies in the working costs have been effected, and it has consequently been possible to provide power ringing at a number of small exchanges where the annual charges have hitherto been prohibitive.

SMALL FLASH  
LAMPS.

142. An inspection lighting set consisting of a small lamp and secondary cell has been designed and a number of the sets have been manufactured and placed in service.

The lamp

The lamp is intended for the use of maintenance men engaged in the clearing of faults on apparatus located in dark positions. The special features which have been borne in mind and provided for in the design of the combination are economy in upkeep, life, lightness and an unepillable cell.

143. About four hundred loose leaf diagrams have been prepared for the use of engineers and men engaged on apparatus maintenance duties. An index and a scheme for the satisfactory distribution of the diagrams to the men who are actually concerned with the upkeep of the plant have been prepared.

LOOSE LEAF  
DIAGRAMS.

144. Detailed instructions for the installation of the fire emergency equipment have been drawn up and are available for use in case of need.

FIRE EMER-  
GENCY  
EXCHANGE  
EQUIPMENT.

The three thousand line universal switchboard equipment has been completely overhauled and modified to meet present day requirements. The separate 1200 line equipment has also been similarly dealt with.

145. A special plant has been designed and procured for carrying the load at any one of the larger exchanges. A considerable amount of flexibility in the electrical arrangements has been introduced in view of the fact that the character of the load which may have to be carried varies considerably as a result of the different voltages of the exchange systems. In co-operation with the Stores Department, arrangements were made to modify two of the larger lorries and provide them with the necessary gear

EMERGENCY  
POWER PLANT  
FOR TELEPHONE  
EXCHANGES.

for the

for the running of the plant which would be accommodated only in case of emergency. Two complete working trials have been undertaken since the set was completed; in one case particularly heavy peak loads being carried during both the morning and afternoon run in one of the largest telephone exchanges. A satisfactory service was maintained throughout the day during which period the whole of the exchange power plant, including batteries, was disconnected from the system.

FAULT  
PROCEDURE.

146. The procedure to be followed in dealing with exchange faults throughout the country has been unified and full instructions covering the day to day practice and the preparation of periodical statistics have been prepared and issued.

TRANSMISSION  
STANDARDS.

147. Previous to 1914 the standards of transmission recognised by the Department in designing telephone plant were based on the standards agreed upon with the late National Telephone Company and embodied in the Purchase Agreement of 1905.

The fusion of the Department's and the National Telephone Company's plant and the subsequent expansion of the whole system gradually rendered these standards inapplicable; the extension of communication with the Continent also affected the outlook.

These facts, together with the foreseen developments in long distance trunk cables necessitated a re-study of the transmission question. As a result new standards were adopted and an instruction on the subject was issued in May, 1915. A further important instruction dealing with transmission in regard to the design of Private Branch Exchanges was prepared and incorporated

in the

in the Instructions referred to in Section 134.

Both these Instructions involved a considerable amount of experimental work.

148. A complete instruction on the subject of loading telephone cables has been prepared but its issue is withheld on account of advance information recently received from America as to very important improvements in the design and manufacture of loading coils.

LOADING  
TELEPHONE  
CABLES.

149. During the period of the war the telephone repeater has developed from what was little more than a laboratory exhibition apparatus to what is now a very practical apparatus of immense value. It has already revolutionised the whole scheme of long distance communication and will effect economies of far greater extent than any previous invention.

TELEPHONE  
REPEATERS.

The telephone trunk programme for 1913-14 provided for the erection of long distance lines requiring 1200 pounds of copper per circuit mile. The current programme provides lines equally efficient with a copper weight of 80 pounds per circuit mile.

This saving is due almost entirely to the Telephone Repeater.

Previous to 1914 the Telephone Repeaters available for commercial service were of the mechanical type, but although the apparatus was almost perfect in design and construction it could not be relied upon in actual service unless in the hands of a highly skilled engineer. The possibilities of the thermionic valve were hardly realised at that time although at least two inventors had patented the use of the valve as an amplifier of minute high frequency currents.

Late in 1913 and during the earlier months of 1914 the Department's Engineers co-operated with the Engineers of the  
Belgian

Belgian and German Administrations in carrying out a series of trials on lines made up between London and several towns in Germany, using thermionic valve Amplifiers at Telephone Repeaters.

The amplifier used was the invention of two German Scientists, <sup>Lishon</sup> Lishon and Reisz, who were invited to bring specimens of their apparatus to London.

The apparatus was delivered in about the same time the Department had under test an Amplifier of the DeForest's Audion type.

The experiments between London and Germany were of course interrupted by the war, but from that time onwards there has been rapid progress in the development of the Valve Amplifier in its application to Telephony. This progress has of course been greatly facilitated by the immense development in valve design and manufacture for wireless purposes in connection with the war, but the problem of the telephone repeater is quite distinct from the wireless problem although the use of particular forms of valve may be common to both arts. The development of the Telephone Repeater has been carried out entirely by the Department's own engineers.

Telephone Repeater Stations have been installed at Birmingham, Buckingham, Gloucester, Chatham, Dover, Maidenhead and Marlborough.

The estimates for the current year provide for the installation of Telephone Repeaters at various stations in the Country, and include the provision of a number of Cord Circuit switching Repeaters at the larger Trunk

Centres which will greatly facilitate long distance traffic over the existing lines.

The most difficult problems of the Telephone Repeater at the present time are the design of efficient transformers for passing speech currents into and out of the valve and the design of artificial lines for balancing. Much useful work has already been done, and since increased staff has been available considerable progress has been made.

The manufacturers of valves have now been able to take up the problem of the Telephone Repeater Valve and it appears probable that important improvements in this direction will be forthcoming.

A reference to the use of Telephone Repeaters in connection with the maintenance of War Communications is made in Section 86.

150. The problems of superposing telegraphs on telephone lines, and of designing cables to carry both telephones and telegraphs have been taken up again now that increased staff is available and an extensive series of experiments has been commenced. Already it has been demonstrated that up to a distance of 200 miles composite cables for long distance loaded telephone lines and high speed telegraphs may be designed and cables of this kind are included in the current construction programme.

COMPOSITE  
TELEGRAPH &  
TELEPHONE  
CIRCUITS.

POWER, TRANSPORTATION, HEATING LIGHTING, &C.

151. Trials were made at Woolwich with a full sized 4-wheel wagon with satisfactory results, both as regards the type of rolling stock and the method of control proposed under the model scheme. Following these experiments, the plans and specifications for the electrical equipment of the Railway were proceeded with and completed so as to be ready for the invitation of tenders as soon as might be expedient.

POST OFFICE  
(LONDON)  
RAILWAY.

Satisfactory

Satisfactory experiments were also made with a form of bag elevator which it is proposed to employ at certain of the underground stations, and the plans and specifications for the whole of the conveyors and lifts required were subsequently completed.

The construction of the tunnel has been completed apart from the work in connection with the permanent way and certain work at the Railway Stations which is dependent upon the electrical equipment.

#### POWER.

152. The plans and specifications for the proposed Sub-Station at Mount Pleasant and for the additional power plant which would be required at the Blackfriars Power Station, if the latter is retained, have been completed. The question of obtaining an extra high tension bulk supply from the public companies has been under consideration but it was decided that the Blackfriars Power Station should be maintained for the present. Owing to the present uncertain position due to the Government proposals in connection with the supply of electric power in bulk, an interim scheme has been prepared to enable satisfactory arrangements to be made for removing certain plant in the existing generating station at Mount Pleasant to enable the building of the first portion of the New Letter Sorting Office to proceed and to provide for the electric supply to that new building without installing additional generating plant at Blackfriars.

The policy of closing down the Department's generating stations in the Provinces has been continued; the stations at Manchester, Glasgow and Amiens Street, Dublin, have been closed down and current taken from the respective Corporations, with a view to effecting considerable savings.

The power/

The power services at Birmingham Factory have been considerably extended to provide further manufacturing facilities in connection with war work, and motors and generators have been provided for temporary war purposes in several other places.

The important question of maintaining the coal supplies at the various Offices where such fuel is still required has necessitated constant attention and co-operation with the Office of Works.

153. Considerable progress has been made with the PNEUMATICS. work of modernizing existing pneumatic installations at the principal provincial Offices, and also at the C.T.O. where the alterations have allowed of a considerable reduction in the working pressure and vacuum resulting in large economy in energy consumption, while giving an improved service on the tubes.

The pneumatic work also included several street tubes for connecting up newspaper offices with the local Post Offices.

154. When war broke out a large amount of work was being done in installing lifts and also conveyors in aid of postal processes, and several installations were subsequently completed. CONVEYORS AND LIFTS.

In connection with aids to letter sorting, a model was constructed to illustrate the combination of facing, sorting, stamping and stacking processes, with incidental transportation, and while this scheme, after investigation by the Traffic Authorities, was not adopted, some of the principles involved have been approved and will be embodied in installations which have already been authorized but which have been postponed until the end of the war.

A separate/



L.

A separate scheme has been evolved for dealing with the sorting of parcels and the necessary plans have been prepared for use at the New Parcel Office at Liverpool.

ELECTRIC  
TRUCKS.

155. Two electric battery trucks have been brought into use at Paddington and two at Bristol, and have done good service in connection with the transportation of mails between the Railway Station platforms and the adjacent Post Offices.

HEATING  
AND VEN-  
TILATION.

156. A large number of heating installations have been taken over from the Office of Works and a large number of new installations and extensions have been dealt with by this Department. A considerable number of ventilation schemes have also been carried out by this Department.

Statistics respecting power, lighting, heating, etc., services are given in Appendix X, which shows the position as at 31st March, 1917, but which has not been appreciably modified since that date.

RESEARCH.

INTER-  
CHANGE OF  
INFORMA-  
TION  
BETWEEN  
BRITISH  
AND  
FRENCH  
POST OFFICE(105667/16).

157. An agreement was made between the British and French Administrations for the exchange of technical information between the Departments of the British and French offices engaged in Telegraph and Telephone Research (105667/16). This resulted in the exchange of numerous official instructions, reports, and detailed information, from the date of the agreement until April, 1918. The work of the Research Staff in this Office after that date until the end of the last financial year was, however, largely of a confidential nature and possibly the same state of things existed in France with the result that there has been no recent exchange of information due entirely to war conditions.

158. The wires of all underground loaded telephone cables, excepting those cases of Western Electric Company contracts completed and in course of construction during this period have been jointed in accordance with a system of testing and selection devised by my Research Staff.

BALANCING  
OF UNDER-  
GROUND  
TRUNK  
CABLES.

This system practically eliminates overhearing or noise in such cables and renders possible the efficient working of long Trunk Telephone Cables whereby the principle of superposed working can be fully utilised. In this manner such cables will have a traffic capacity 50% in excess of similar cables which are not specially balanced.

The investigation of this problem and its subsequent solution gave rise to considerable mathematical analysis, necessitated the design of apparatus of unusually high precision and sensitiveness for use out of doors under all conditions of weather, and involved the training of special staffs to carry out the work along the routes of the cables. A comprehensive instruction embodying the results of the Department's latest experience has just been completed. The immunity from disturbances secured by balancing has been proved latterly to be a most important factor in the successful operation of telephone repeaters.

It is estimated that considerably over 50,000 tests have been made during the period covered by the War, in addition to which a large number of final tests of loaded cables were made. These latter tests were made primarily to ascertain whether the cables were accurately loaded, but the experience gained brought to light many unsuspected faults and showed the tests to be of great value in fixing and maintaining a high standard of cable transmission efficiency.

AERIAL  
LOADING.

159. Two aerial loaded circuits have been fitted on the poles and completed between Leeds and Glasgow, in continuation of the loading scheme formerly completed between London and Leeds. The Leeds - Glasgow coils are of a cheaper type than those used between London and Leeds, and were made according to the Department's instructions as a result of the experience gained during the former experiments. The experiments and tests which have been made on the newly loaded circuits, show that the expectations respecting the performance of the new type of coil are fully justified. The result is that a considerable economy in the cost of aerial loading is obtained without any material sacrifice of transmission efficiency. Owing to circuit rearrangements necessitated by war conditions, it has not yet been possible to bring the loading scheme for the London - Glasgow loaded circuits fully into use.

NON-  
CORRODIBLE  
STEEL FOR  
SUBMARINE  
SHEATHING  
WIRE &c.

160. The most suitable material for the sheathing wire of submarine cables has been the subject of enquiry, and investigations have shown marked differences in the life of commonly employed qualities of iron due to different rates of corrosion in sea water. The information so far obtained is of much value in dealing with commercial samples.

Some very remarkable results have been obtained as the outcome of researches which have been made in the laboratory of new alloys containing chromium as a distinctive constituent, and the provision and investigation of a series of alloys containing the most economical proportion of this metal has been started. Some of these alloys show practically no corrosion in sea water after six months trial and possess superior mechanical qualities, advantages/

advantages which it is hoped will more than compensate for the somewhat higher price of raw materials. It has been calculated that a saving of weight of nearly 7 tons per nautical mile with correspondingly greater flexibility, can be effected by the use of a special alloy in the case of a new cable recently designed. An effort is being made to obtain tenders for a cable sheathed with the new material as an alternative to iron sheathing wire.

The suitability of the material for use in the manufacture of certain parts of telephone apparatus in which its good mechanical properties and non-corrodibility would be very advantageous has been investigated and some promising preliminary results obtained. The pressure of urgent war work and the want of larger facilities prevented the investigation being proceeded<sup>ed</sup> with during the latter stages of the war.

161. A new type of continuously loaded submarine cable has been designed to link up the system of high efficiency underground loaded cables across narrow seas and estuaries.

SUBMARINE  
CABLE CON-  
TAINING  
28 WIRES.

The problem arose for the first time of providing within the practical dimensions of a submarine cable a large number of moderately low attenuation circuits which would be free from cross-talk and could be used for bearing "phantom" circuits with the same facility as the cables they link up. One of the factors of cross-talk, i.e. mutual induction has been eliminated in underground cables by a formation known as "Multiple twin" but this being mechanically unsymmetrical cannot be employed in Submarine cables. The difficulty has been surmounted for the first time by introducing a graduated series of twists in the various "quad cores" of the submarine cable formation, and employing special connections at each end of the submarine section.

General/

GENERAL.

WIRE MILEAGES.

162. Appendix Y contains a summary, from particulars furnished by the Accountant General, of wire mileages of the Post Office Telegraph and Telephone systems as at 31st March 1914 and 31st March 1919.

NEW DESIGNS.

163. Some particulars of the most important of the new apparatus designs produced by this Department during the war period for departmental purposes are given in Appendix Z.

APPARATUS  
SUPPLIES.

164. The statement marked Appendix AA shows the value of the Telegraph and Telephone apparatus, excluding war items, purchased during the period 1st April 1914 and 31st March 1919.

JOINT EXAMIN-  
ATION SYSTEM.

165. The Joint Examination system (introduced in 1913) of grading apparatus immediately on receipt has demonstrated its value increasingly, since not only is there the minimum of handling, but instruments of no further use are scrapped on the spot instead of being stored for considerable periods as was formerly the case. Items fit for immediate re-issue are transferred direct to new stock (without incurring any expenditure or book entries) and are thus ready at once for re-circulation.

In the absence of definite statistics it is estimated that about 1,500,000 items were dealt with during 1914-15 and, 1,250,000 items during 1915-16. There was a considerable falling off in the quantities dealt with during 1916-17 and 1917-18 but for the year just closed there has been an upward movement, the number of items being approximately 1,280,000.

166. The policy of scrapping old and useless stores has been consistently followed during the war period but in view of the probable Army, Colonial and Allied requests for apparatus and also in view of the high cost of new supplies and difficulty in obtaining them it was not considered advisable to scrap material as freely as would otherwise have been practicable. This action was fully justified as large numbers of instruments have been supplied to the Army, the Colonies and the Belgian Government. The total reduction in value of surplus apparatus stock is estimated to be about a quarter of a million pounds. If to this total be added the value of the Line Stores held in March 1918 for War Office requirements and the value of Tools returned to Depot, it will be found that the material held has actually been reduced to approximately £400,000 as compared with March 1914.

SURPLUS  
STOCKS.

167. Much attention has been devoted to schemes for cheapening and improving underground construction works.

UNDERGROUND  
CONDUITS, ETC.

For underground conduits, earthenware ducts of the single and of the multiple-way type have been largely used. Considerable use has also been made of earthenware U troughs for minor underground conduits. The design of the U trough has been improved. In the new type, the joints and covers are cemented when laid so as to prevent the ingress of soil into the troughing.

Earthenware pipes 3" and 4" and U troughing have largely superseded cast iron pipes for single way routes. Creosoted wood troughing, which was designed as an alternative to earthenware, showed a saving in labour as compared with earthenware troughing, but owing to the large increase in the price of wood, the manufacture of wood troughing for our use was discontinued two or three years ago.

A method of drying and rendering non-hydroscopic the exposed ends and joints of paper core cables by treatment with very hot paraffin wax has been investigated and adopted for general use. The system expedited jointing and renders the insulation of the cables less liable to failure.

A system of desiccating paper core cables by means of Carbonic Anhydride gas as used in France has been under experimental trial and shows a considerable economy over the dry air process used by the Department.

Considerable economies have also been effected during recent years by constructing manholes entirely of reinforced concrete.

STANDARD-  
ISATION OF  
LINE STORES.

168. The question of standardising a considerable number of items used in the construction of overhead and underground lines is receiving attention at the hands of the British Standards Association, and a good deal of information has been prepared and placed at the disposal of the Committee concerned.

MECHANICAL  
TRANSPORT

169. Careful consideration has been given to the question of adopting a system of motor transport and a scheme has been suggested involving the supply to the Districts of 36 three-ton motor lorries, 80 seven-cwt. motor vans, and 500 motor cycle combinations, at a capital value of approximately £88,400. It is intended that the vehicles shall be obtained, as far as possible, from surplus stock held by the Ministry of Munitions.

DIVERSION  
FROM CITY AND  
SOUTH LONDON  
RAILWAY.

170. In connection with the widening of the City & South London Railway Company's tunnels between Moorgate Street and Clapham Common the Department in 1915 was called upon to divert an important network of telephone

cables

cables from railway property. The cables, which had been acquired from the ex National Telephone Company, contained approximately 5,000 junction circuits and in order to provide for the diversion, more than  $7\frac{1}{2}$  miles of new pipework and 14 miles of cables, containing 5,860 miles of circuit, were laid and brought into use. In all  $23\frac{1}{2}$  miles of cable, weighing in the aggregate 400 tons were removed. The work of removing the old cables from the tunnels, platforms, and lift shafts of the railway, which could only be carried out between the hours of 12.35 a.m. and 3.50 a.m., with an extension to 6.30 a.m. on Sunday mornings, was commenced on the 10th November, 1915, and completed on the 9th December, 1915, 3 weeks in advance of the specified time.

171. The numbers of suggestions received from the Awards Committee for consideration and the numbers adopted either as originally submitted or with modifications were as follows:-

"AWARDS"  
SCHEME.

1914-15	192	suggestions	received,	71	adopted
1915-16	115	"	"	42	"
1916-17	107	"	"	27	"
1917-18	98	"	"	41	"
1918-19	107	"	"	23	"

172. A statement is enclosed (Appendix BB) showing the approximate total quantity and value of cable, wire, apparatus, woodwork, ironwork, etc. examined and reported on by my Test Branch during each year since 31st March 1914. As stated in Section 45 considerable quantities of these Stores were specially tested for the Military Authorities.

PLANT TESTS.

173. Up-to-date technical instructions relating to Pneumatic Tubes, Letter Stamping Machines, Protection from power circuits, Maintenance Testing, Fault

TECHNICAL ETC.  
INSTRUCTIONS.

Procedure



Procedure, Quadruplex Telegraphy, and a Cash Accounting Pamphlet and Line stores Ready Reckoner have been printed and issued, while the distribution of Technical Literature has been co-ordinated and Schedules have been issued showing the Instructions to which each grade is entitled.

CONFERENCES  
OF SUPERIN-  
TENDING  
ENGINEERS.

174. A Conference of Superintending Engineers was held at Southport from the 5th - 8th May, 1914. The Agenda was a formidable one and included many subjects of great importance including the arrangements to be made for carrying out an unprecedented programme of Construction &c. work.

The circumstances in relation to the Engineering Programme for 1915-16 were such as rendered it essential that a Conference should again be held and the Superintending Engineers accordingly met at Birmingham on the 12th and 13th May, 1915. Questions arising as a result of the Department's policy of reducing work to a minimum in the present emergency were given special consideration, and important matters relating to Organisation, Staff Accounting, etc. were discussed.

APPRECIATION.

175. In concluding this Report I desire to say how highly I have appreciated the ability, the loyalty and the zeal displayed by my staff in the work of the Department during the strenuous years of the war. Much has been demanded of them in the maintenance of the telegraph and telephone system, in the provision of urgent war services, in solving the many new problems which have arisen, and in adapting themselves to exceptional circumstances and I am indebted to all grades, both Engineering and Clerical, for the energy, skill, and self-sacrifice which have been readily given.

It

It will be evident from the information furnished in this report, that the Engineering Department has been of immeasurable assistance to the Navy, the Armies at home and abroad, and to the many new Government Departments and it is impossible to imagine what would have been the consequences had <sup>that</sup> assistance not been afforded regardless of personal inconvenience, hardship and peril. The small regular signalling force constituting the K. Company of the Royal Engineers (108 Officers and men) was of course quite inadequate for the requirements of the Armies and it is no exaggeration to say that the members of the Engineering Staff who joined the forces constituted the backbone of the Signal Service. So far as the maintenance of cross channel communication was concerned this Department had to take the whole of the responsibility, the French Government not having attempted a single job either in the way of repairs to or diversion of an existing cable or the laying of a new cable.

Where the services rendered have been so uniformly whole-hearted, it is somewhat difficult to individualize merit and appreciation but I have reviewed the work very carefully and have great pleasure in bringing to special notice the undermentioned officers, *for their services in connection with the war,* viz:-

MR. A.L. DeLATTRE, Staff Engineer in Charge of Main and Local Lines Sections, was my right hand in Submarine Cable work and rendered very valuable services. He had also to provide and arrange for the external plant for Home Defence purposes &c.

MAJOR T.F. PURVES, R.E., Staff Engineer in Charge of the Designs Section, responsible for the design and provision of apparatus for the use of the Armies in the field.

MR. J. SINNOTT, Staff Engineer in Charge of the Construction Section, who devoted himself to the provision of enormous quantities

quantities of line stores, many of which were specially designed to meet special requirements.

MR. S.A. POLLOCK, Staff Engineer in Charge of the Research Section, who devised many schemes and appliances in connection with Anti-Submarine work, sound ranging, and the destruction of enemy stores and munitions.

MR. E.H. SHAUGHNESSY, O.B.E., Staff Engineer in Charge of the Wireless Section, responsible for the equipment maintenance and working of Direction Finding Stations, detection of illicit signalling and limitation of the manufacture and use of wireless apparatus.

MR. E.J. IVISON, Assistant Staff Engineer, who took charge of the Telephone Section from 1st October 1918 and in that capacity carried an exceptional burden.

CAPTAIN B.W. COHEN, R.A.F., Assistant Staff Engineer, who was placed at the service of the Admiralty and the Air Force and devised many appliances for signalling between Air Craft and Aerodromes, and for overhearing prisoners' conversation.

MR. E. LACK, M.B.E., Assistant Staff Engineer in Charge of the Telegraph Section, vice Lt. Col. Booth who was withdrawn to act as Assistant Director of Army Signals. Mr. Lack worked out in detail the schemes for working the <sup>several</sup> ~~several~~ long distance telegraph cables with remarkable success and was very helpful in assisting other Administrations.

MR. A.B. HART, Assistant Staff Engineer, who was particularly valuable in connection with long distance telephone circuits, especially where submarine cables were involved.

MR. H.P. BROWN, M.B.E., Assistant Staff Engineer, who was responsible for the telephone systems introduced in connection with Home Defence and Aircraft warfare.

MR. A.H. ROBERTS, Executive Engineer, who assisted Mr. Lack generally, and spent a long period in North Russia in connection with the Murmansk-Yukanski-Archangel Cable.

MR. R.M. HOOK, Assistant Engineer who, was transferred temporarily to the Submarine Staff and had charge of the converted trawler "Madia" which acted as Cable Ship to the fleet based in the Forth.

MR. C. LEIGH, Assistant Engineer, who after employment under Mr. DeLattre was transferred to the Submarine Staff and acted as Cable Engineer on several of the large Cable Ships in use by this Department.

MR. J. LOCKHART, Chief Inspector, who went to Halifax, N.S., with the "Colonia" and installed the cable equipment there and remained in charge until the Pacific Cable Board was able to take over the control.

Of my Submarine Staff, I would specially mention

MR. J. BOURDEAUX, O.B.E., Submarine Superintendent, who was on board the Colonia and has been in charge of the Submarine staff and its operations since the sinking of the old "Monarch".

MR. H.F. BOURDEAUX, O.B.E., Commander of the "Alert" who has been most exceptionally zealous in the expeditious and successful completion of the many important works entrusted to him and who was on many occasions in great peril.

MR. F.G. RAMSAY, M.B.E., Commander of the "Monarch" who has undertaken many perilous expeditions and has been very successful in promptly carrying out his instructions.

MR. D.B.S. SAVILLE, M.B.E., Chief Engineer, "Alert".

The District Staff has of course rendered excellent service, the more prominent being

MR. A. MOIR, O.B.E., Superintending Engineer, London District who has had a very arduous time in maintaining the requirements of the War Office, Admiralty and new Departments.

MR.

MR. J. McL. ROBB, O.B.E., Superintending Engineer, South Midland District, who, in addition to the control of one of the largest districts, had to meet the requirements of the Military Authorities in a larger measure than any other Superintending Engineer.

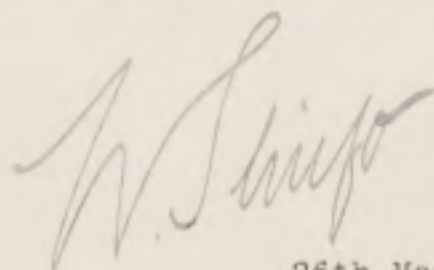
MR. E. GOMERSALL, O.B.E., Superintending Engineer, Ireland District, who was specially brought under notice for his excellent work consequent upon the rebellion in Ireland.

MR. G.F. GREENHAM, M.B.E., Assistant Superintending Engineer, London District, who acted as Liaison Officer between this Department and the War Office in connection with the Anti Aircraft operations.

MR. E.A. PINK, Executive Engineer, Bristol, who with a small staff went to Dunkerque and installed an extensive telephone equipment for the British Commodore.

MR. H. DOAK, Assistant Engineer, Dublin, who on his own initiative went to Amiens Street Station when the Rebellion broke out in Dublin, and getting into communication with this Office, gave the first intimation as to what was happening.

I cannot close this list without making special mention of the great assistance I have received from MR. E.S. ROBERTS, Second Class Clerk, my private secretary, until he took his commission in December 1915, and from MR. F.C. LUCAS, Third Class Clerk, who acted in Mr. Roberts' place until his return in January last.



26th May, 1919.

## SCHEDULE OF CABLES LAID OR PROVIDED SINCE THE OUTBREAK OF WAR.

DATE	C A B L E.	NO OF CORES	LENGTH OF CABLE	WORK CARRIED OUT BY	APPROX. COST (CABLE CHARGES ONLY) £.	SERVICE	REMARKS
Sept '14	Dunkirk - Cherbourg	1	200	"John Pender"	9,474	French	150n.m of German cable used in position
"	Cherbourg - Brest	1	277	"John Pender"		"	"
"	Jersey - St. Malo	1	42	"Electra"	12,828	Anglo-French	
"	Beachy Head - St. Nazaire	1	475	"Telconia" & "Dacia"	28,771	"	233n.m of German Cable used in position
Oct. '14	Dartmouth - Jersey	1	91	"John Pender"	1,455	English	
"	St. Margarets - Dunkirk	1	39	"John Pender"	1,027	"	
Jan'y '15	Peterhead - Alexandrovsk	1	1427	"Colonia"	270,964	Anglo-Russian	
" '16	Dungeness - Audrecelles No. 1	6	26	"Telconia"	16,177	Anglo-French	
" '17	Penzance - Fayal	1	1310	"Monarch" and "John Pender"	374,181*	English	1290 n.m of German Cable used in position.
July '17	Fayal - Halifax	1	2040	"Colonia"		English	1688 n.m of German Cable used in position *Includes cost of work on French Brest-Fayal-New York Cable.
Feb'y '17	Dover - Dunkirk	4	42	"Telconia" and "Morsey"	70,658	Anglo-French	
July '17	Alexandrovsk - Murmansk	1	22	"Faraday"	17,216	Anglo-Russian	
Aug. '17	Murmanek - Yukanski	1	302	"Faraday"	172,038	Anglo-Russian	
"	Yukanski - Archangel	1	380	"Faraday"		"	"
July '17	Across Kola Inlet	1	2	"Faraday"	50,712	Russian	
Sept '17	Intzi - Pyalitzza (across White Sea)	4	33	"Faraday"		Russian	
"	Archangel - Bakaritzza	4	2	"Faraday"		Russian	
"	"	4	2	"Faraday"		English	
Aug '17	Dover - Sangatte No. 1	4	21	"Telconia"	15,874	Anglo-French	
Sept '17	Cuckmere - Havre No. 1	4	67	"John Pender"	46,982	Anglo-French	
Feb. '18	" " No. 2	4	65	"John Pender"	49,940	American	
May '18	Dungeness - Audrecelles No. 2	4	23	"John Pender"	27,512	Anglo-French	
"	" " No. 3	4	24	"John Pender"	21,907	"	
Nov. '18	Dover - Sangatte No. 2	4	21	"Monarch"	20,158	"	
Feb. '19	Brest - Fayal	1	1476	"Sialkot" and "Colonia"	See * above	French	1353 n.m of German cable used in position and also 112 n.m of Brest-Cherbourg cable (referred to above) used in position.
	Total Cable mileage		8270		1,137,848		
	" wire "		9274				

## Appendix A. (Contd).

NUMBER AND LENGTH OF SUBMARINE CABLES PROVIDED  
FOR THE ADMIRALTY, IN THE ORKNEYS, FIRTH OR FORTH, &c.,

## HUMBER AREA.

Cable	No. of cables	Total length	Total wire Mileage.
		n.m.	n.m.
1 core	2	10.164	10.164
2 core	12	22.552	45.104
4 core	3	5.869	23.476
<b>TOTALS</b>	<b>17</b>	<b>39</b>	<b>79</b>

## MISCELLANEOUS.

Cable	No. of cables	Total length	Total wire Mileage
		n.m.	n.m.
1 core	13	186.153	186.153
2 core	8	6.659	13.318
3 core	1	0.372	1.116
4 core	21	18.177	72.708
6 core	-	-	-
8 core	2	8.754	70.032
12 core	1	1.198	14.376
16 core	9	10.377	166.032
28 core	1	0.193	5.404
20 wire lead Cov'd	2	0.214	4.280
32 " " "	1	0.140	4.480
48 " " "	1	0.127	6.096
50 " " "	1	0.197	9.850
204 " " "	1	0.202	41.218
<b>TOTALS</b>	<b>62</b>	<b>233</b>	<b>595</b>

Appendix A. (Contd).

NUMBER AND LENGTH OF SUBMARINE CABLES PROVIDED  
FOR THE ADMIRALTY, IN THE ORKNEYS, FIRTH OF FORTH, &C.  
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ORKNEYS & SHETLANDS AREA.

Cable	No. of cables	Total length n.m.	Total wire Mileage. n.m.
1 core	12	103,760	103,760
2 core	52	38,202	76,404
4 core	32	33,412	133,648
6 core	2	3,369	20,214
8 core	9	9,647	77,176
12 core	2	2,000	24,000
16 core	6	3,295	52,720
TOTALS	115	193,685	487,922

FIRTH OF FORTH AREA.

Cable	No. of cables	Total length n.m.	Total wire Mileage n.m.
2 cores	19	26,333	52,666
4 cores	20	43,898	175,592
8 cores	10	9,889	79,112
16 cores	2	5,511	88,176
28 cores	1	2,000	56,000
TOTALS	52	88	452



## SUMMARY.

AREA.	No. of cables laid.	Cable Mileage	Wire Mileage	Approximate Cost.
Orkneys and Shetlands	115	194	488	) £195,676
Forth	52	88	452	
Humber	17	39	79	
Miscellaneous	62	233	595	
International and Cables for Foreign Administrations.	25	8230*	9274*	£1,137,848
<b>TOTALS</b>	<b>271</b>	<b>8784</b>	<b>10888</b>	<b>£1,333,524</b>

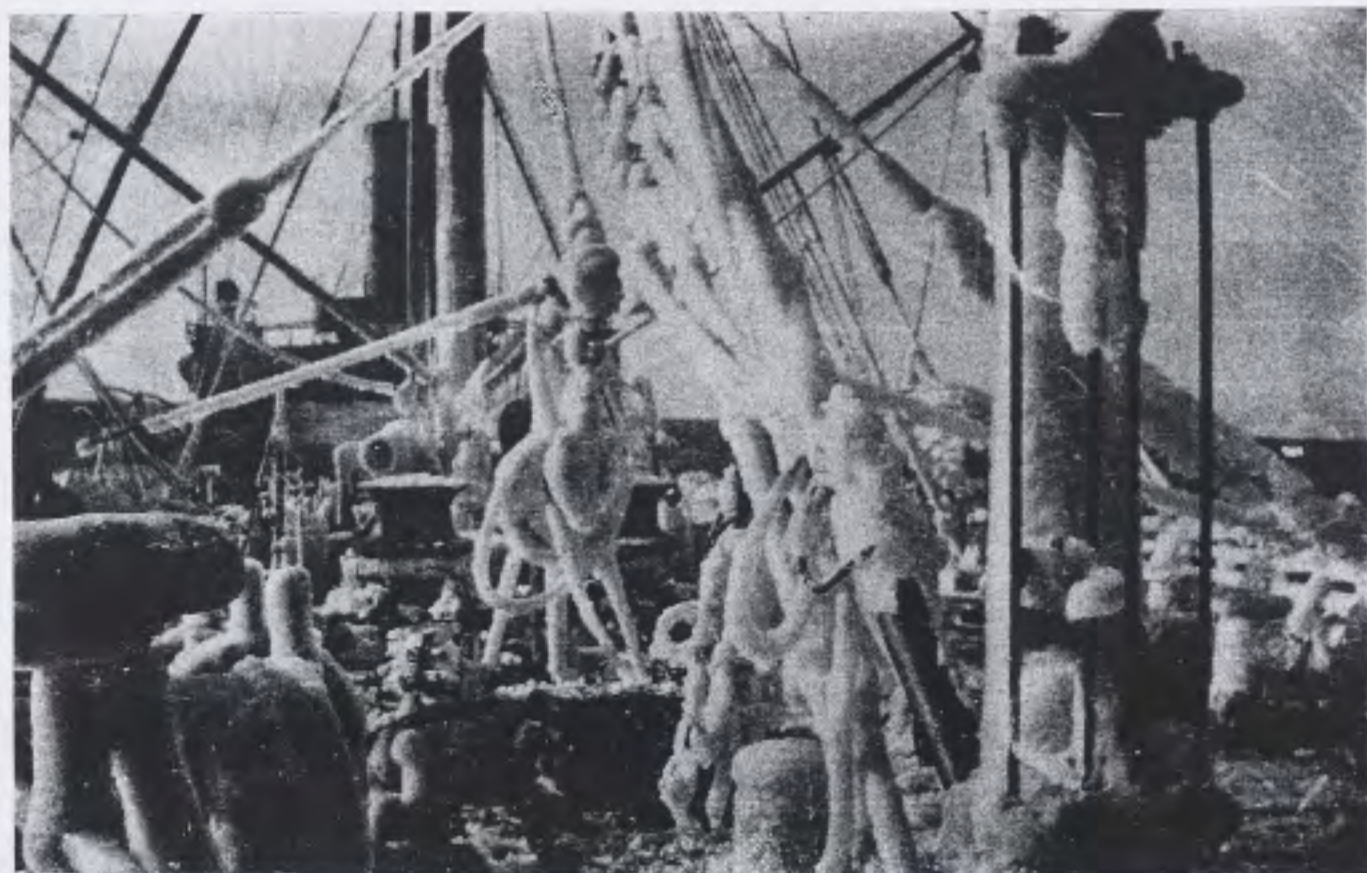
\* Includes 5066 n.m. cable and wire used in position.



TELEGRAPH CONSTRUCTION & MAINTENANCE CO'S CABLE SHIP "COLONIA"  
EMPLOYED BY THE POST OFFICE IN CONNECTION WITH THE PETERHEAD-ALEXANDROVSK  
AND IMPERIAL CABLES

*TONNAGE 7976 TONS*

*LENGTH - 501 FEET*





TELEGRAPH CONSTRUCTION & MAINTENANCE CO'S CABLE SHIP "COLONIA"  
EMPLOYED BY THE POST OFFICE IN CONNECTION WITH THE PETERHEAD-ALEXANDROVSK  
AND IMPERIAL CABLES  
TONNAGE 7976 TONS                      LENGTH - 501 FEET



THE "COLONIA" ENTERING HALIFAX HARBOUR AFTER  
ENCOUNTERING A BLIZZARD IN THE ATLANTIC, MARCH 1917.



1. The "COLONIA" looking forward from the Bridge.



2. Grappling in 3000 fathoms water.



3. Getting a Lucas cutting Grapnel on board.



4. Lowering a buoy on deck.



5. This buoy will hold up a weight of over 5 tons in water.



6. Heaving in the Grapnel Rope.



7. Picking up a buoy mooring.



8.



9.



10.



11.



12.

8,9,10,11 & 12. Phases in slipping a final splice. The weight on either side of cable is from 5 to 6 tons and great care is therefore taken so as not to damage the cable and cause a fault.



13. The measuring wire gear.



14. The Lucas cutting and holding grapnel.

## SCHEDULE OF CABLE BELONGING TO GERMANY PICKED UP DURING THE WAR.

Appendix C.

Cable	Approximate positions between which German cable picked up.	Approx. length n.m.	Type	Date	Cable ship engaged.	Disposal of cable picked up.
Borkum-Fayal (1903)	Long 1°14'00"E } 4°59'00"W Lat 50°55'00"N } 49°38'30"N	246.912	500 $\frac{10}{2}$	Aug. - Nov. 1914	"John Pender"	(Dartmouth n.m. 91.188 English cable (Jersey (St. Margarets (Dunkirk 38.598 English cable (War service) (Peterhead 66.260 Jt. Anglo- (Alexandrovsk Russian cable Balance used on several (Lightship 20.866 English cable (cables &c. <u>246.912</u>
Borkum-Teneriffe	Long 1°30'30"W } 3°1'30"W Lat 50° 2'00"N } 49°44'00"N	60.392	600 $\frac{10}{2}$	do.	-do-	(Dunkirk (Cherbourg 10.590 French cable (do. repair (where cut 1.508 French cable (Brest (Cherbourg 35.582 French cable (Balance used (on several (Lightship 12.804 English (cables &c. cables <u>60.392</u>
Borkum-Fayal (1900)	Long 5°2'00"W } 3°35'30"W Lat 49°51'15"N } 50° 8'00"N	58.667	1 core	Nov. 1918	"Monarch"	Discharged into Department's cable tanks at Plymouth and Woolwich.
	Long 0° 2'00"W } 1°30'30"W Lat 50°33'45"N } 50°22'00"N	61.3		"	"Hodder"	
	Long 1°30'30"W } 3°12'00"W Lat 50°22'00"N } 50° 9'00"N	60.05		"	"Hodder"	
	Long 3°35'30"W } 3°28'30"W Lat 50° 8'00"N } 50° 8'00"N	5.45		"	"Hodder"	
						<u>185.467</u>

SCHEDULE SHEWING LENGTHS OF GERMAN CABLE UTILISED IN SITU  
IN CONNECTION WITH BRITISH AND FRENCH CABLES.

Cable	Approximate positions between which German cable utilised.	Length n.m.	Type	Used for
Borkum-Tencriffe	Long 1°30'30"W } 1°48'45"E) Lat 50° 2'00"N } 51° 8'30"N)	150	1 core	Dunkirk-Cherbourg French cable
Borkum-Brest	Long 2° 2'00"W } Brest Lat 50°15'00"N }	240	1 core	Cherbourg-Brest French cable afterwards partly for Brest - Fayal French cable
Borkum-Vigo	Long 0°24'40"E } 5° 2'20"W) Lat 50°28'40"N } 49° 4'18"N)	233.544	1 core	Beachy Head-St.Nazaire Anglo-French cable
Borkum-Fayal (1900)	Long 5°26'40"W } Fayal Lat 49°45'35"N }	1290	1 core	Penzance - Fayal Imperial cable
Fayal-New York (1904)	Fayal Long 61°48'05"W) Lat 39°40'00"W)	1688	1 core	Fayal - Halifax Imperial cable
Borkum-Fayal (1903)	Long 4°59'30"W } Fayal Lat 49°38'15"N }	1352.93	1 core	Brest - Fayal French cable

## VESSELS CHARTERED FOR CABLE REPAIRS.

NAME OF VESSEL	OWNERS	DATE CHARTERED		WORK	RATE PER DIEM.
		FROM	TO		
"John Pender"	Eastern Telegraph Coy.	30 Aug. '14	11 Novr. '14	English Channel	£120
"		18 Aug. '17	15 Sepr. '17	Cuckmere-Havre Cable	£112
"		23 Dec. '17	25 Feby. '18	English Channel & Cuckmere-Havre	£ 93
"		7 Apl. '18	21 May '18	Dungeness-Audrecelles 2 & 3 cables	£100
					plus coal, plus 7½%
"Teleconia"	Telegraph Construction and Main- tenance Coy.	14 Aug. '14	17 Sepr. '14	Birling Gap-St.Nazaire cable	£ 70
"		19 Jan. '15	10 July '15	Various	£ 76
"		15 Sepr. '15	13 July '16	"	£ 80
"		24 Aug. '16	16 Mar. '17	"	£ 90
"		7 July '17	11 Aug. '17	Dieppe repair & Dover-Sangatte cable	£110
"Dacia"	India Rubber Cutta Brocha & Telegraph Works Coy.	2 Sepr. '14	18 Sepr. '14	Birling Gap-St.Nazaire cable	£130
"Electra"	Eastern Tele- graph Coy.	9 Sepr. '14	25 Sepr. '14	Jersey-St.Malo cable	(£ 60 (loading) (£100)
"Colonia"	Telegraph Construction and Main- tenance Coy.	10 Decr. '14	10 Feby. '15	Peterhead-Alexandrovska	£200
"		29 Octr. '16	2 Novr. '17	Fayal-Halifax cable	£330
"		14 Jany. '19	3 Apl. '19	Penzance-Fayal cable repair	£410
"Faraday"	Siemens Bros.	7 May '17	17 Novr. '17	Russian cable work	(£ 70 (loading) { £250 (£180 Jersey to Thames (Main Work)
"Minia"	Western Union Tele- graph Coy.	28 Apl. '18	7 Decr. '18	Atlantic cable repairs	{ 7/ 1350 Halifax to Plymouth { 7/ 1000 to termination of charter



CABLE SHIPS, TRAWLERS & C. EMPLOYED ON SUBMARINE CABLE WORK  
(EXCLUDING CHARTERED VESSELS).

Appendix F.

VESSEL	DATE FROM	TO	WORK	REMARKS
H.M.T.S. MONARCH (old)	4 Aug. 1914	8 Sepr. 1915	General Cable Work	Mined and sunk 8 Sepr. 1915.
do. MONARCH	August 1916	Still employed	do.	
do. ALERT (old)	4 Aug. 1914	August 1917	do.	Subsequently sold.
do. ALERT	1 May 1918	Still employed	do.	
MERSEY	April 1915	Still employed	do.	
RODDER	May 1915	January 1919	Admiralty work in Orkneys & English Channel.	
Trawler ETOILE POLAIRE	October 1915	October 1915	Lightship repairs in Thames Estuary	Soon after mined and lost with all hands.
do. LADY KATE	July 1917	August 1917	do.	Replaced by Edward VII.
do. EDWARD VII	Nov. 1917	Still employed	do.	Release expected this month (May 1919)
do. RADIS	July 1917	Still employed	Admiralty work in Firth of Forth.	
do. ST. HUBERT	January 1918	July 1918	General Cable Work in English Channel.	
do. SIALKOT	June 1918	January 1919	do.	
do. DENTARIA	June 1917	June 1917	Newbiggin-Sondervig repair.	
do. TRANSVAAL	November 1917	March 1918	Peterhead-Ekersund repair.	

SCHEDULE SHOWING NUMBER OF EMERGENCY WORKS CARRIED OUT  
FOR THE WAR OFFICE, ADMIRALTY, MINISTRY OF MUNITIONS, NATIONAL  
SERVICE DEPARTMENT, & ROYAL AIR FORCE.

PERIOD	DEPARTMENT	Circuits Provided	Circuits rearranged	Circuits extended	Circuits discontinued	Miscellaneous works such as the provision of switchboards additional receivers, long ear cords etc.	Extension circuits recovered	Circuits transferred from private Renters	TOTAL NUMBER OF WORKS	
8 months ended 31.3.'15	* War Office & Admiralty	6181	1494	3230	750	672	327	951	13614	
Year ended 31.3.'16	* War Office & Admiralty	6413	2745	2591	2413	1304	668	237	16374	
	Ministry of Munitions	324	64	70	9	41	3	7	518	
Year ended 31.3.'17	* War Office	6331	2269	2897	1787	1350	587	134	15355	
	* Admiralty	1286	579	450	299	399	84	18	3131	
	Ministry of Munitions	1938	570	870	129	485	75	42	4115	
	National Service Department.	18	5	3	-	1	-	-	27	
Year ended 31.3.'18	War Office	6877	2991	3977	2294	2018	821	144	19122	
	Admiralty	1880	773	770	429	706	95	35	4688	
	Ministry of Munitions	1183	403	521	168	324	77	5	2741	
	National Service Dept.	130	60	90	46	42	7	3	429	
	Royal Air Force	1146	173	479	92	174	53	-	2117	
Year ended 31.3.'19	War Office	4700	3081	2236	2608	1251	982	79	14937	
	Admiralty	1779	891	596	853	631	429	51	5230	
	Ministry of Munitions	530	341	317	466	220	214	7	2095	
	National Service Dept.	2971	1023	715	1129	362	571	11	6782	
	Royal Air Force	713	501	547	410	112	415	42	2740	
									GRAND TOTAL	114014

\* Includes works for Royal Air Force.

FRENCH SWITCHBOARDS

Number  
ordered

Buzzer Switch-Units 7 lines & 10 lines.— Small self-contained and self-packing switchboards of simple and robust design. Used since the year 1916 as the standard type of buzzer switchboard throughout all the British Areas. The units are lined up en suite to provide exchanges of the capacity required.

36000

Magneto Switch-Units 5 line & 10 line - Magneto ringing switchboards similar in size and construction to the above and adapted to stand en suite with them when mixed magneto and buzzer lines have to be operated from the same point.

4950

Switch-Unit with Visual Buzzer Call Indicator 8 lines.— Designed to utilise a type of indicator, captured from the Germans, in which a rotating visual vane is ingeniously combined with a buzzer call receiver. The case has been made of the same size and shape as that of the buzzer and Magneto Units mentioned above and is used en suite with them.

1000

Cordless Magneto Switchboards 5 line & 10 line. The above switchboards were designed early in the War. The 5 line size is not much used but the 10 line size has become the standard type of that capacity throughout all the British War areas. They are entirely self contained, robust in construction, and transportable without need for packing. They have no connecting plugs or cords; all connections are made by the manipulation of switching keys.

4700

Buzzer Switchboard with Visual Indicators, 12 lines. This is a more highly developed buzzer switchboard designed to utilise the German visual indicator. It provides for 10 external and 2 internal lines and is complete with operators telephone set. Switching Keys and a cord and plug shelf are provided and the whole admits of very rapid operation.

300

TELEPHONE SWITCHBOARDS FOR MULTIPLE EXCHANGES  
AT BASE OFFICES.

A modified type of 60-line floor pattern switchboard, with provision for multiple switching was introduced and used in fitting up the large exchanges installed at bases and main headquarters.

SWITCHBOARDS FOR THE LINES OF COMMUNICATION AND  
LARGER FORMATIONS.

Many standard types of P.C. telephone switchboards were specially adapted for War use and fitted in combined stands and packing cases designed to facilitate transportation and rapid erection in situ. Several hundreds of these have been supplied. At a later stage new types of collapsible and self-packing switchboards were designed, and were equipped, to the utmost possible degree, with appliances for facilitating transport and assembly, as well as for minimising and expediting the work of the operators.

The type of mobile exchange designed for Army Headquarters

and.

SOME PARTICULARS OF PRINCIPAL ITEMS OF  
TELEGRAPH AND TELEPHONE APPARATUS WHICH  
HAVE BEEN SPECIALLY DESIGNED AND SUPPLIED  
BY THE POST OFFICE FOR THE R.E. SIGNAL  
SERVICE DURING THE WAR.

<u>TELEPHONE SWITCHBOARDS</u>	Number ordered
Buzzer Switch-Units 7 lines & 10 lines.- Small self-contained and self-packing switchboards of simple and robust design. Used since the year 1916 as the standard type of buzzer switchboard throughout all the British Areas. The units are lined up on suite to provide exchanges of the capacity required.	36000
Magneto Switch-Units 5 line & 10 line - Magneto ringing switchboards similar in size and construction to the above and adapted to stand on suite with them when mixed magneto and buzzer lines have to be operated from the same point.	4950
Switch-Unit with Visual buzzer Call Indicator 8 lines- Designed to utilise a type of indicator, captured from the Germans, in which a rotating visual vane is ingeniously combined with a buzzer call receiver. The case has been made of the same size and shape as that of the Buzzer and Magneto Units mentioned above and is used on suite with them.	1000
<sup>to</sup> Cordless Magneto Switchboards 5 line & 10 line. The above switchboards were designed early in the War. The 5 line size is not much used but the 10 line size has become the standard type of that capacity throughout all the British War areas. They are entirely self contained, robust in construction, and transportable without need for packing. They have no connecting plugs or cords; all connections are made by the manipulation of switching keys.	4700
Buzzer Switchboard with Visual Indicators, 12 lines. This is a more highly developed buzzer switchboard designed to utilise the German visual indicator. It provides for 10 external and 2 internal lines and is complete with operators telephone set. Switching keys and a cord and plug shelf are provided and the whole admits of very rapid operation.	300

TELEPHONE SWITCHBOARDS FOR MULTIPLE EXCHANGES  
AT BASE OFFICES.

A modified type of 50-line floor pattern switchboard, with provision for multiple switching was introduced and used in fitting up the large exchanges installed at bases and main headquarters.

SWITCHBOARDS FOR THE LINES OF COMMUNICATION AND  
LARGER FORMATIONS.

Many standard types of P.O. telephone switchboards were specially adapted for War use and fitted in combined stands and packing cases designed to facilitate transportation and rapid erection in situ. Several hundreds of these have been supplied. At a later stage new types of collapsible and self-packing switchboards were designed, and were equipped, to the utmost possible degree, with appliances for facilitating transport and assembly, as well as for minimising and expediting the work of the operators.

The type of mobile exchange designed for Army Headquarters

and large "locality" offices consists of 40-line collapsible sections arranged to receive, when necessary, an independent "Multiple" consisting of hinged Jack-boxes, permanently wired together, with cable tails finishing on connection strips which can be simply and rapidly connected to the Line Test Frame at one end, and to the local answering positions at the other end. By this means (and in association with the 160-line portable Test Frame referred to elsewhere in this appendix) a complete multiple exchange for as many as 320 lines can be carried about, and can be set up, or dismantled and placed intact, on transport, in about an hour. This is considered to be a unique feature.

For Divisional H.Q. Offices, Artillery "Group" H.Q., the larger Brigade Offices and corresponding locality exchanges, a 20-line collapsible switchboard, of floor pattern was provided. This has 10 pairs of plugs and cords and is also arranged for block wiring. It is specially arranged for the addition of an auxiliary 10-line Magneto, or Buzzer, Switch-unit when necessary, and can thus be used to make up exchanges (of 20, 30, 40, 50 or 60 lines) the capacity of which can be readily modified to suit the requirements of different formations which may have to occupy the position successively, while armies are advancing or retiring.

TRENCH TELEPHONES.

Teles.Nos. 92, 100 & 110. Self-contained magneto ringing telephones, capable of withstanding rough usage and exposure, and transportable without need for packing cases; were designed for the use of the army early in the War. In the earlier types apparatus parts in existing stocks were, as far as possible used as fittings. The latest form is known as Telephone No. 110 and the Director of Signals in France agreed in 1917 that it should be the only type of magneto telephone supplied for ordinary exchange use as well as for Trench use. 40000

Telephone No. 110B. This is a modified form of the above Trench Telephone No. 110. In addition to the Magneto Signalling apparatus a buzzer and special call key are added in order to adapt the set for use by an operator at a combined buzzer and magneto exchange. The operator's speaking circuit is terminated on a 4-way Jack so that a hand telephone or head-gear set may be used, as desired. 2000

Telephone No. 92A. A modified form of the above Trench Telephone No. 92, adapted in the year 1915, for use with portable drums of twin cable, in the linking up and control of Anti-Aircraft Mobile Guns, by means of the Post Office Exchange System. The connections are so arranged that the Instrument can be used on "Common Battery", "Common Battery Signalling", or "Magneto" Exchange Lines. In practice the nearest subscriber's office was utilised to obtain the Exchange connection. The subscriber's instrument was, during action, disconnected and locked out by means of a special "Switch 6 Point, 2 Position with Lock". 50

Telephone No. 28 encased. Post Office Telephone No. 28 mounted in a specially designed case with batteries generator &c. Introduced to relieve temporary shortage of other trench and table telephones. 1700

Telephone No. 108. Special Telephone sets introduced for operators in connection with Buzzer Visual Switchboards. 2000

Telephone No. 44A. An adaptation to military purposes of a P.O. lineman's portable magneto telephone by the addition

	Number ordered
of a buzzer and call key. This enables a military lineman to call and communicate on any class of circuit (buzzer or magneto) which he may have to deal with.	8100

Telephones No. 100A & 110A and Telephone Sets Roadgear Anti-Aircraft in case. These instruments were designed for use in connection with the "Height Finders" supplied to the Army in France for determining the effective range of hostile aircraft. They provide, by means of Plugs and a Jack, for the alternative use of hand set or head set by the telephonist.	2000
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Telephones No. 105 & 112. Hand combination telephones for military use, designed for equipment of P.O. War telephones generally, on account of inadequate manufacturing output of the distinctive War Office types of hand telephones	43000
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------

Telephone No. 104. A simple and cheap telephone without calling facilities of any kind. Designed for use as message sets adjacent to switchboards and as extension sets in the same room as the main instrument. Its introduction enabled an equivalent number of much more costly complete telephone sets to be set free for general use.	500
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----

MOBILE LINE - TESTING EQUIPMENT FOR DIVISIONAL  
AND BRIGADE OFFICES.

This equipment includes the following main items :-

Test Panels 12-line	7000
" " 4-Transformer	500
" " 2 "	1500
" " Galvo	2200
" " P, 6-pair	6 patterns

The above provide portable equipment for the protection and testing of lines, for cross-connecting line and apparatus sets with a minimum of trouble and for forming superimposed telegraph and "phantom" Telephone circuits. Each piece is hinged across the centre and can be shut up with a spring catch, in which condition it is readily transportable without packing. All mobile units in the field are now equipped with this apparatus which is standard throughout the British armies.

TEST FRAME, PORTABLE, 160 PAIRS AND 80 PAIRS.

STRIPS, TRANSFORMER BRACING, FOR PROTECTORS, FUSE AND TEST, NO.4002.  
PROTECTORS, TEST NO.4001.  
TEST-TABLET, EC 1144.  
STRIPS, CONNECTION NO.50  
TRANSFORMER NO.3 (DOUBLE).  
PLUGS NO.218  
PLUGS NO.112

The above items with the auxiliary fittings mentioned were designed with a view to the supply of a readily transportable Standard type of test, protector, and distributing frame, for use at large Military offices such as the Headquarters of Armies and Corps. A sample frame for 160 pairs was constructed and

taken.

Number  
ordered.

taken to France with the suggestion that its introduction would greatly facilitate the movements of the signal offices of those formations. The proposal was approved and the frames were adopted as standard, on an issue basis of four frames to each Army and two to each Corps. 100 Frames were therefore provided.

100

The Main Frame is in four parts which are packed in a travelling case measuring about 36" x 24" x 16". This case also forms a stand upon which the parts of the frame can be speedily erected and fixed together ready for use. Provision is made for rapidly adding and connecting transformers to any extent that may be necessary for the formation of superimposed circuits, and also for lacing out and terminating the line and Switchboard cables upon 10-pair connection strips which fit on the terminal strips of the test frame and can readily be attached and detached as a whole. A test panel, with switching keys, is included, where by the making of the various tests is rendered very rapid and practically automatic.

At a later stage the military authorities asked for a supply of frames of similar type, but smaller capacity, for the equipment of Divisions. An 80-pair frame was therefore designed; 75 were ordered and the necessary number issued.

75

LAMP SIGNALLING SYSTEM FOR OBSERVATION OF FIRE  
OF ANTI-AIRCRAFT GUNS.

Cases, lamp signalling, gun spotting.

Cases, press button, gun spotting.

These items were designed to meet the desire of G.H.Q. Home Forces, for the provision of a means whereby the results of anti-aircraft gunfire could be communicated to the gunners by visual signals controlled by observers stationed about a mile from the gun. Two observers are stationed in positions so chosen that one or both can secure flank observation, and report whether shells are bursting beyond or short of the target. Each is in telephonic communication with the gun position and wears a headband receiver in which he hears the report of the gun. His signalling set is provided with three press buttons, the first of which, when pressed, lights a green lamp at the gun position, indicating that the shot is short; the second lights a red lamp indicating that the shot has passed over the target; the third lights both green and red lamps and indicates that the range is correct. 1000 sets of equipment for the two ends of the circuit were provided, and were in general use until the system of aiming and correcting individual shots was superseded by group, and barrage, firing. 1000

FULLERPHONES.

The Fullerphone is a morse telegraph instrument based on a suggestion put forward some years ago by Major Fuller, R.E. Its characteristic is the use of a very small and graduated signalling current, at low voltage, which produced practically no disturbance in adjacent circuits. Its use in the war was

dictated

dictated by the very important consideration that Fullerphone signals could not be overheard on enemy listening sets. (With the highly developed listening sets now available the signals of an ordinary buzzer instrument, as used at the beginning of the War, can be heard at several miles distance from the circuit). The Fullerphone principle can be applied in many different ways both mechanically and electrically and in order to provide a first supply the P.O. was asked to endeavour to produce such instruments from apparatus and parts held in stock. 3650 sets of different designs, have been supplied. The latest is associated with a complete telephone set for independent, and non-secret, communication. Other designs have now been obtained in large numbers by the War Office and the Fullerphone is now the only type of buzzer telegraph used in positions near the army fronts.

3650

SOUND RANGING APPARATUS.

Holders, Microphone, (Marks 1, 2, 3 & 4). These are specially constructed brass containing boxes for the above microphones, provided with connections for attachment to the air-containers, mentioned below, with which they are used.

2400

Testboards, 40 Pair. For protection, testing and balancing of the circuits radiating from each observation headquarters to the Microphone Stations.

112

Instruments, Ranging, 6 slide. This is a non-electrical device of a mathematical character, for rapidly calculating graphically, the difference between the position of a hostile gun, previously located, and the point of impact of a shell fired against it. Its use, under favourable conditions, enables the correction, for each shot, to be signalled to the gunners within a few seconds. The instrument was devised, in principle, by the Sound Ranging Section in France who forwarded a rough model upon which the design was based.

36

Test boxes, 2, 4, 8 & 16 pairs. - small weather-proof test-boxes for fixing in the field, providing for distributing, testing and maintaining the circuits (generally surface cables) connecting the microphones with the Sound Ranging Headquarter Stations.

600

Containers, Air, Microphone - They are cylinders of sheet metal with graded ventholes, and have conical ends, to one of which the Microphone-holder is attached. They are sheltered, along with the necessary protective apparatus, by emplacements constructed locally.

860

Protectors, Test, No. 201. - Device with two vacuum tube lightning protectors and Test links.

500

FLASH SPOTTING APPARATUS.

This system is used to ascertain the positions of enemy guns by observation of the flash on discharge. Angular cross-bearings on the flash are reported by 4 or more observers and the positions of the hostile gun is

located,



located graphically on a map. Each installation covers four or five miles of front and for the last two years of the War the whole of the British Army Fronts were equipped with the apparatus mentioned below:-

Switchboard, Flash & Buzzer, 4-line. This switchboard provides for four observation points connected by wire to the Headquarters Station. Calling Signals are sent by magneto generator. Full telephonic communication among the observers, and with the controlling operator, is provided, and any observer can also be switched through to the General Exchange Switchboard at the Headquarters station. A system of lamp signals is also provided, in association with a buzzer system which can be placed under the control of any observer who may be in the best position to direct the operation and by means of which the other observers can be guided to recognition of the particular flash which it is desired to locate. The lamp signals enable the controlling operator at Headquarters to assure himself that all the observers are working to the same flash before he requests them to notify, by telephone, its observed bearings. 42

Switchboards, Flash & Buzzer 6-Line (Mark 1). This is a later type of Headquarters control board providing for six observation points. It is a Magneto Signalling Switchboard similar to the 4-line type. 12

Switchboards, Flash & Buzzer 6-Line (Mark 2). This switchboard is adapted for buzzer signalling throughout and was introduced in 1917 with a view to ultimate supersession of the above mentioned switchboards as it was found that buzzer calls could be passed successfully when the condition of the line insulation was too bad for magneto signalling. 75

Press-Key, Flash & Buzzer (Mark 1). This item was supplied for the use of the observers and provides for sending the flash-spotting signal. 150

Press-Key, Flash & Buzzer (Mark 2). This is a later design with the press-key attached to a length of flexible cord in order to allow freedom of movement to the observer. 450

Lighting Set, Survey Post. This set provides technical lighting equipment for the flash-spotting observer. It includes batteries and switches, lamps for illuminating the graticules and the reading scale of his telescope, and a lamp, with long flexible cord, fixed at a datum point in front of the post as a night aiming point. 160

Jack No. 8, Double, with Cord. For attachment of headgear telephone and hand telephone simultaneously to signalling sets used by flash-spotting observers. 300

SPECIALLY DESIGNED FIRE ALARM SYSTEMS  
 AND APPARATUS.

For Explosives Factory, Gretna. The system provides equipment for 55 circuits at two Fire Stations, and for 55 Call Points. An automatic indication is given at the call point when a call has been received, and the system provides central battery telephone communication between

. any.

## Appendix H. (Contd.)

	Number ordered
any point and either of the Fire Stations.	2 switch-boards 60 call points
<u>For Munitions &amp; Stores Dumps in France.</u> 20-circuit switchboards for Central Offices and special call points, providing continuous supervision of line insulation and automatic indication that call has been received.	30 switch-boards 500 call points.
<u>For National Filling Factory No. 14 - Hereford.</u> This system provides equipment for 51 Telephone Fire Call Points and "clear out" Bells.	1 switch-board. 65 call points.

London Fire Brigade Emergency Scheme. A system was designed for the London Fire Brigade to provide for speedy restoration of the Fire Alarm Service in the event of the destruction of one or more of the London Fire Stations by enemy aircraft. Two Wall Switchboards, for use at an ordinary Station, and one floor pattern Switchboard, for use at a Superintendent's Station, were specially manufactured and stored by the Department at the expense of the L.C.C.

Fire Alarm Equipment of the ordinary standard type has also been installed at several places, - Shell Stores, Aviation Schools, &c. - to provide against War Risks.

#### VARIOUS ITEMS.

Screening Buzzers. These are used to produce a jamming electrical disturbance in the earth along our front lines, in order to prevent the overhearing of signals by enemy listening sets. A few were originally supplied by outside electrical contractors but were heavy, costly, and not very satisfactory. The P.O. design is much cheaper and more compact and was in general use during the period of trench warfare. 1500

Bell Set, Trench Mortar Battery. Signalling sets for controlling the fire of Trench Mortar Batteries. 3250

Buzzer Sets, Trench Mortar Battery. Items for same purpose as above which they supersede, but employing a buzzer instead of a bell. 3200

Distributing Cases, 40 Pairs - for handling and inter-communication circuits in deep dugouts at important junctions of buried cable system. By means of these appliances cable conductors can be rapidly redistributed and joined through to make up circuits for the fluctuating requirements of an entrenched front, by means of "jumper" wires, without interfering with the cables themselves. Provision is made for good insulation, ready recording of changes, and security against dirt and damage. 600

Cross-Connecting switch-Cases, 40 pairs. Introduced as an auxiliary to certain exchanges, mainly those concerned in providing communication between groups of

artillery.

Appendix H. (Contd.)  
Number  
ordered.

artillery and forward observing officers. Batteries and observers can be switched through direct, or can be connected to the exchange, according to requirements from day to day. In this way the size of the exchanges required at such communication points was greatly reduced, and space and plant were saved. 700

Arm Grips, were designed for clamping telegraph arms on wooden poles belonging to the French Administration. The use of these grips extinguished the need for paying compensation for the cutting of arm slots in French poles which had previously amounted to a considerable sum. 60000

Transmitter, Watch, with press button: a small and compact telephone transmitter which can be carried in the pocket of an officer who is authorized to speak telephonically on Fullerphone telegraph circuits. 2500

Insulating blocks, adapted for the secure connection of steel field cables on apparatus terminals. 100000

Test Tablets 20-wire, L. of C. hinged and self-packing testboards for 10 pairs of lines used as intermediate test points for circuits on Lines of Communication. 375

Transformers No. 3 Double. Specially designed Transformers mounted in pairs for use with military Test Frames. 2000

Transmitters No. 20 Breastplate transmitter adapted for use in open air positions; introduced for telephone operators at Anti-Aircraft Guns and Searchlights. 2500

Test Set, Portable, No. 1. - is a small instrument designed for the use of military linemen. It is self-contained and complete with battery, calibrated detector and Test Key, and it enables quantitative measurements of resistance and insulation to be made in a very simple way, without any skill on the part of the user. 1200

Muzzle Velocity Calibration Screens (Strip Connection No. 51). Wooden strips, each provided with 54 special terminals for making up screens used by the Field Survey Sections, R.E. in France for computing the muzzle velocity of guns. The screens are made up with a special grade of steel wire and two are erected in front of the gun position. The muzzle velocity is calibrated by observing the time interval (electrically recorded) which elapses between the rupture of the wires of the first and second screen by the passage of the shell. 3000

Instruction Diagrams. Pocket sets of diagrams, in "loose-leaf" binders, have been prepared to illustrate and explain the principal special items designed for the Army. The sets now contain about one hundred diagrams. 4,000 copies were supplied to France, 1,000 to R.E. training centres in England, 850 to the War Office and smaller numbers to other centres and theatres of War. Copies of new diagrams were circulated on the same basis, for addition to the set, as completed.

High-Tension Fuses, for open air fitting; to protect military lines and offices in France against damage by Power Circuits in the industrial and colliery areas. 12000

## Appendix II. (Contd.)

Number  
ordered.

<u>Test &amp; Protector Case, 3 pair;</u> for Junction points between open and buried lines in France. Provides lightning protection and testing and connecting facilities.	400
<u>Search Coils.</u> - These coils are of light construction and are rectangular; measuring about 4 ft. by 2 ft. Each is connected to a headgear-receiver worn by the man who carries the coil. When so equipped he can hear, by induction, buzzer signals passing over buried cables at a depth of 8 feet and over. The coils are used for locating faults in buried cables and for tracing cable routes the tracks of which have been obliterated by shell fire. They have also been useful in tracing the routes of enemy buried cables, after the occupation of his ground, and of bringing them into useful service in cases where their condition remains sufficiently good for the purpose.	164
<u>Buzzer No. 2A.</u> Small buzzer designed for sending a vibrating call on various military lineman's telephones.	3500
<u>Buzzer No. 13 A.</u> Buzzer specially designed for first type of Fullerphone supplied by the Post Office.	1770
<u>Buzzer No. 13 B.</u> For second type of Fullerphone supplied by the Post Office.	2400
<u>Buzzer No. 14 A.</u> Designed for Screening Buzzers No. 1.	200
<u>Buzzer No. 14 E.</u> Designed for Screening Buzzers No. 3 and for various telephone and buzzer switchboards.	2400
<u>Drum, Cable, Single Conductor.</u> Portable drum carrying half mile single conductor cable for direction of fire of Admiralty Anti-Aircraft fixed position guns.	24
<u>Drum, Cable, Twin Conductor.</u> Carries half mile twin steel cable. Used by Admiralty and War Department for direction of fire of Anti-Aircraft Mobile Guns, nearest subscriber's telephone circuit used as connecting point.	60
<u>Drum Wire Z3.</u> Special Drum with detachable check, arranged for reeling up bronze wire recovered from aerial lines and forming it into coils for subsequent use.	1350
<u>Ear Pads No. 1.</u> Pneumatic rubber cover and ring attachable to telephone headgear receiver; to exclude extraneous sounds. Used by telephonists at Anti-Aircraft Batteries at Home and Overseas.	9000
<u>Generator No. 20A.</u> Introduced for military switchboards and magneto telephones after the Post Office supply of Generators had become exhausted.	24000
<u>Generator, Pedal Driven.</u> Powerful foot-driven generator actuated by pedal crank; designed to expedite operating of military switchboards by relieving the operator of hand ringing.	700
<u>Gramophone Morse Records.</u> These were prepared with graded lessons at various speeds to assist in the training of operators in reading Morse Buzzer Signals.	5000

Headbands.

## Appendix H. (Contd.)

	Number ordered.
<u>Headbands Nos. 1, 2, &amp; 3.</u> Flexible headbands of webbing and elastic; for supporting headgear telephones in connection with various apparatus sets.	10000
<u>Indicator, Buzzer Visual, Nos. 1A &amp; 2A.</u> Special indicator providing visual indication of the receipt of buzzer signals. Copied from captured German Apparatus.	16000
<u>Indicator &amp; Jack No. 1 &amp; Indicator &amp; Key No. 7.</u> Combinations of Indicators with Jacks and Keys for use with magneto switch units.	1000 each
<u>Indicator &amp; Key No. 6.</u> Special combination of self restoring Indicators and Keys for use on 40-line portable switchboards.	300
<u>Keys 69F, 69FN, 72MB, 72MC, 73C.</u> Key adaptations and combinations introduced for Buzzer and Magneto Units and Portable Switchboards.	2000
<u>Key 5C, Metal Frame.</u> Cheap, strong and compact single current Morse Key designed for use on Fullerphones, Telephone and Buzzer Sets &c.	9100
<u>Plug No. 301 A.</u> Special plug with end adapted to act as Listening Jack for Buzzer and Magneto Switch Units &c.	73000
<u>Protectors, Fuse &amp; test No. 4002.</u> 20-wire strip with fuses and lightning protectors for military test frames.	1500
<u>Protectors Test No. 4001.</u> 20-wire strips, lightning protectors only, for military test frames.	500
<u>Relay 171A.</u> Special relay for Flash-Spotting Switchboards.	300

In your reply }  
please quote }

No. Maps 4015/97.

*APPENDIX I.*

GENERAL HEAD QUARTERS,  
BRITISH ARMIES IN FRANCE.

15th September, 1916.

Sir,

I am informed that the officers in your Department, and especially the officer in charge of Research in the Engineer-in-Chief's branch, have been so good as to give great assistance to an officer of my Head-Quarters recently sent Home in connection with Sound Ranging.

I would be glad if you would accept yourself, and convey to the officers concerned, ~~My~~ thanks for the courtesy shown and the assistance rendered, which has been of material advantage towards furthering military operations.

I have the honour to be,

Sir,

Your obedient Servant,

*D. Haig.*

General,  
Commanding-in-Chief,  
British Armies in France.

The Postmaster-General,  
General Post Office,  
LONDON.

UP 8.39. DAILY SKETCH, FRIDAY, AUGUST 7, 1914.

**PROTECTING TELEGRAPH OFFICES AGAINST BOMBS.**



The Government are taking every precaution to safeguard telegraphic communication against bomb throwers by placing torpedo netting over the most important offices.

APPROXIMATE COST OF WAR ENGINEERING WORK.

Appendix J.

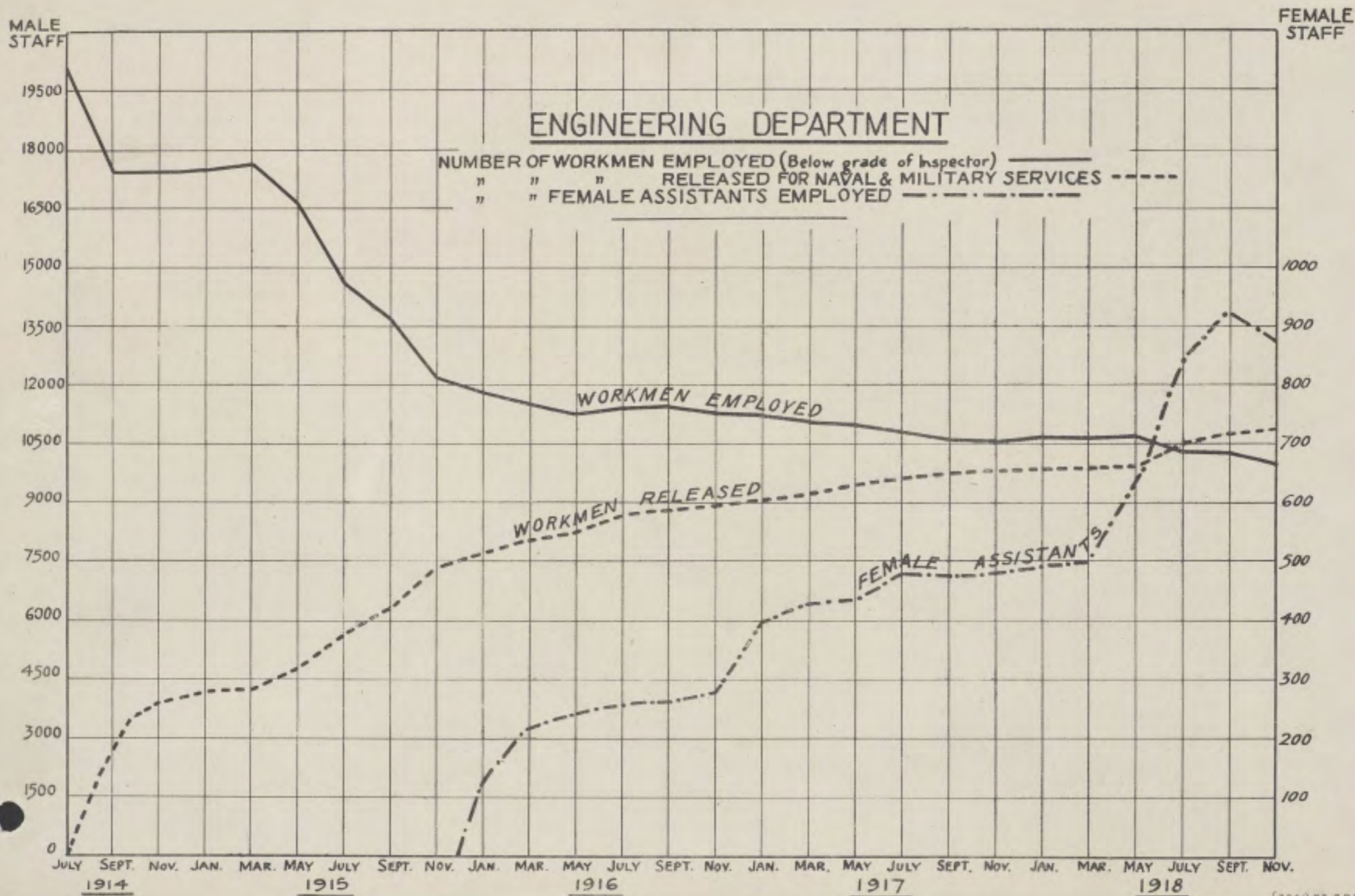
Appendix J.

Item	8 months ended 31.3.15		Year ended 31.3.16		Year ended 31.3.17		Year ended 31.3.18		Year ended 31.3.19		Totals	
	£	£	£	£	£	£	£	£	£	£	£	£
<u>Construction</u>												
Emergency Cots.	212,019		260,269		484,731		593,054		785,000		2,335,073	
Submarine Cables	168,789		42,489		146,898		230,524		-		588,700	
Stores supplied for War Comms.	31,703		285,763		1,352,233		2,703,273		2,041,000		6,393,972	
Renovals & Re-arrangement of Plant	-		6,417		11,712		16,812		-		34,941	
<u>Maintenance</u>												
Emergency Cots.	-		15,456		30,070		44,034		46,100		135,660	
Submarine Cables	-		30,810		20,256		45,373		-		96,439	
War Emer. Wireless Stns. (Working expenses)	-		3,243		4,067		-		-		12,310	
		412,511		649,447		2,029,967		3,633,070		2,872,100		9,597,095
<u>Other charges, viz</u>												
War Bonus proper to work other than War Work	-		96,118		97,190		296,447		553,400		1,043,163	
Net cost of substitution of Eng. staff called to the Colours or loaned to other Government Depts.	111,162		397,726		467,416		499,584		519,850		1,995,736	
Miscellaneous	6,650		74,257		84,666		95,417		244,100		505,090	
		117,812		568,101		649,280		891,448		1,317,350		3,543,091
<b>TOTALS</b>		530,323		1,217,548		2,679,247		4,524,518		4,189,450		13,141,086



SCHEDULE SHOWING THE NUMBER AND ESTIMATED VALUE OF CONTRACTS PLACED DURING THE FINANCIAL YEARS ENDED 31ST MARCH, 1914, 1915, 1916, 1917, 1918 AND (PARTLY ESTIMATED) 1919.

Year ended 31st March	Total number of contracts placed	Estimated total value £	Laying Conduits (Separate Contracts).		Annual Contracts for laying conduits, providing drawing in and jointing cables		Main Cables; providing, drawing-in and Jointing cables.		Telephone Exchange Equipment, Extensions and Alterations (including Repairs to Storage Batteries).		Power work (includes Electric Lighting, Lifts, Hoating, Power and Pneumatic Plant).		Miscellaneous (including Wireless Plant and Cable Ship repairs).	
			No.	Estimated Amount £	No.	Estimated Amount £	No.	Estimated Amount £	No.	Estimated Amount £	No.	Estimated Amount £	No.	Estimated Amount £
1914	886	2,180,606	294	265,272	8	1,040,000	20	530,982	92	284,358	277	33,511	195	6,485
1915	724	1,025,317	229	222,513	4	200,000	24	402,208	92	122,828	234	50,853	141	27,118
1916	327	140,201	55	25,808	-	-	-	-	44	64,540	161	18,783	67	11,290
1917	212	50,460	27	4,946	-	-	-	-	29	16,705	61	6,665	75	22,144
1918	258	26,224	22	5,897	-	-	-	-	30	10,264	124	4,372	82	5,691
1919	316	244,212	25	17,527	-	-	4	138,170	36	76,706	138	5,358	113	6,453



Appendix M.

Return showing total numbers of all ranks absent on  
Naval and Military Service on 1.12.1918 and total  
numbers demobilised up to 28.3.1919.

-----  
(excluding members of K. Telegraph Co.R.E.)

Staff Withdrawn	Total Staff in H.M. Forces on 1.12.1918.	Total number demobilised.		
		"Demobilisers"	Others	Total
Staff Engineers	2	1	-	1
Asst. Staff & ) Asst. S.E.'s )	9	2	-	2
Executive Engrs.	9	5	2	7
Assistant Engrs.	57	18	5	23
Chief Inspre. & ) 2nd Class Engrs )	56	16	7	23
Inspectors	184	50	30	80
Principal Clerk	1	1	-	1
2nd Class Clerks	9	4	1	5
3rd Class Clerks	272	74	54	128
Asst. Clerks or C.A's	971	129	271	400
Temporary Clerks	55	-	5	5
Short. Writers & Typists	45	1	9	10
Boy Clerks	40	-	13	13
Junior Cler. Assts.	54	-	5	5
Draughtsmen (estd.)	26	19	3	22
Draughtsmen (unestd.)	120	36	24	60
S.W. Class I	160	43	24	67
" Class II	1,990	448	403	851
U.S.W.	3,748	758	905	1,663
Labourers	2,848	319	788	1,107
Boys & Youths	2,043	38	67	105
Adult & Boy Messgrs.	25	-	8	8
Wayleave Officers	75	10	16	26
Tradesmen	47	7	18	25
Other grades	31	5	12	17
<b>T O T A L S</b>	<b>12,877</b>	<b>1,984</b>	<b>2,670</b>	<b>4,654</b>

Appendix N.

ENGINEERING DEPARTMENT.

NUMBERS OF STAFF OF DIFFERENT GRADES ACTUALLY EMPLOYED  
AT 31ST MARCH, 1916, 1917, 1918 AND 1919.

GRADE.	NUMBER			
	1916	1917	1918	1919
<u>Administrative and Clerical Staff.</u>				
Engineer-in-Chief	1	1	1	1
Assistant Engineer-in-Chief	2	2	2	2
Principal Power Engineer	1	1	1	1
Consulting Engineer	1	-	-	-
Accountant	1	1	-	-
Principal Clerks	2	2	2	3
Clerks, Supplementary Establishment	39	32	32	56
Clerks, Superintending Engineers' Offices	434	425	394	449
Assistant Clerks	106	61	57	160
Boy Clerks	52	39	29	35
Clerical Assistants	272	181	178	426
Junior Clerical Assistants	54	16	-	-
Temporary Clerks, etc. Male and Female	581	590	558	402
<u>Construction and Maintenance Force.</u>				
Suptg. Engrs, Staff Engrs, & Supts. of Cable Ships	26	24	23	23
Asst. Suptg. and Staff Engrs. and Asst. Supts. of Cable Ships	52	50	49	49
Executive Engineers & Executive Cable Engineers	98	96	91	97
Navigating and Engineer Staff, Cable Ships	9	8	19	20
Assistant Engineers and Assistant Cable Engrs.	244	203	208	254
Second Class Engineers		36	33	33
Junior Engineers	18	12	10	14
Building Overseer	1	1	1	1
Chief Inspectors and Inspectors	954	829	812	888
Skilled Workmen (Established)	5650	5554	5449	5968
(Unestablished)	3099	2956	2973	3930
Test Clerk Class I	-	1	1	1
Chauffeurs	1	6	4	5
Draughtsmen (Established)	31	25	22	67
(Unestablished)	54	57	65	84
Wayleave Officers (Established)	40	39	39	37
(Unestablished)	19	18	22	42
Labourers (Unestablished)	1522	1284	1097	2124
Boys and Youths	1727	1753	1487	1310
Minor Staff on Cable Ships (Established)	50	38	43	36
(Unestablished)	66	101	89	135
Tradesmen	119	92	82	114
Miscellaneous (Unestablished)	7	6	6	3
Female Assistants	230	420	476	696
Royal Engineer Staff	3	-	-	-
Girl Probationers	-	3	8	13
Female Telephonists on loan	-	-	72	62
<u>Executive and Manipulative Staff.</u>				
Superintendent of Typists, Female	1	1	1	1
Shorthand Writers & Typists, Male & Female	82	116	110	124
Female Tracers	-	17	22	23
Assistant Head Messengers	1	1	1	1
Messengers (Adult) and Commissionaires	3	1	1	1
Liftmen and Doorkeepers	21	3	3	23
Boy Messengers	176	88	44	50
Girl Messengers	-	64	93	92
Cleaners and Charwomen, (Full time)	21	-	-	-
(Part time)	111	123	138	136
TOTALS	15982	15387	14848	17992

Appendix D.

SCHEDULE OF IMPORTANT PLANS, MAPS AND TRACINGS  
PREPARED SPECIALLY FOR THE WAR OFFICE,  
ADMIRALTY, ETC.

1914. Plans of all main line circuits from Isle of Wight to the Wash (War Office).  
quarter inch maps of Main Telegraph routes in connection with their patrol (W.O.)  
Plans showing all circuits in the Channel Cables.  
Cable maps of the world brought up to date (W.O.)
1915. Telephone Exchange maps of Great Britain and Ireland (W.O.)  
Map of British Isles showing all cable landings (W.O.)  
Plans showing transmission of cable messages from Europe to America &c. (Censor, C.T.O.)  
Provincial Boundary map (13 copies) specially marked with Military Districts (Home Defence)  
Circuit plans of Orkneys and Shetlands (Admy.)  
Numerous diagrams in connection with Anti-Aircraft circuits (H.D.)  
Plan of emergency circuits North and South of Thames (H.D.)  
Telegraph route maps of Scotland brought up to date (Coast Guard Department).  
Telegraph route maps of England brought up to date (Admy.)  
Diagram of all coast communication circuits in Norfolk and Suffolk (H.D.)  
3 copies of 5 diagrams showing Wireless Telegraph Station communications in Great Britain (Admy.)  
Diagrams showing all emergency circuits to War Signal Stations (Admy.)  
Large number of Admiralty charts marked up to show routes of War Emergency Cables.
1916. Replacing and marking up charts lost in "Monarch".  
Six sets of Telephone Exchange maps marked to show Air Defence boundaries (H.D.)  
All diagrams in connection with Railway Transport Emergency scheme.  
Map showing Air Warning Controls and Warning Districts. (750 copies printed - W.O.)  
Tracings showing positions of Anti-Aircraft guns &c. (H.D.)  
Maps and plans showing circuits specially provided in connection with Major and Auxiliary schemes for Defence of London (H.D.)

Appendix O (Contd.)

Set of Military maps marked to show P.O. routes (W.O.)

Complete set of maps and plans of England corrected to date (H.D.)

1917.

Plans of communications for Northern and Southern Army Commands.

Diagrams and tracings of Admiralty communications in Great Britain.

Complete set of Telegraph maps of British Isles brought up to date (Admy.)

Maps showing "Barrage" areas (H.D.)

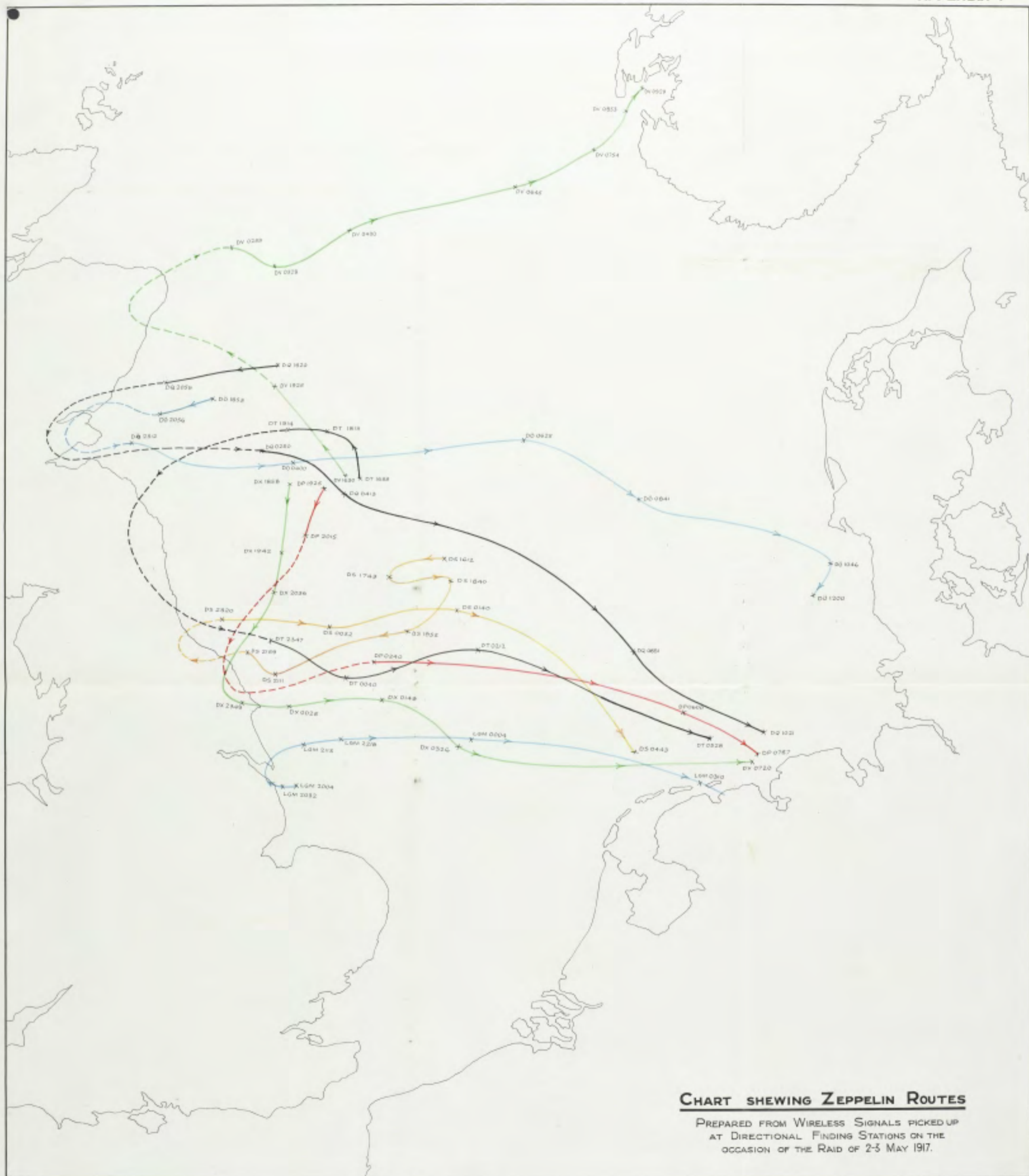
Maps and circuit diagrams in connection with invasion schemes (H.D.)

Plan of London G.H.Q. special circuits (W.O.)

Two sets quarter inch telegraph maps coloured to show Air Warning Districts (H.D.)

Diagrams showing all circuits provided for Admiralty, War Department, Royal Air Force and American Army and indicating how circuits were made up.

Diagrams of communications for Independent Air Force.

**CHART SHEWING ZEPPELIN ROUTES**

PREPARED FROM WIRELESS SIGNALS PICKED UP  
AT DIRECTIONAL FINDING STATIONS ON THE  
OCCASION OF THE RAID OF 2-3 MAY 1917.

	Parliamentary Grant						Expenditure					
	1914-5	1915-16	1916-17	1917-18	1918-19	Total	1914-15	1915-16	1916-17	1917-18	1918-19 (Estd)	Total
<b>VOTE</b> =====												
<u>Maintenance</u>												
Telegraphs	276,000	256,730	358,000	261,500	281,000	1,312,230	260,348	257,328	272,817	262,744	270,400	1,323,636
Telephones	1,581,575	1,608,640	1,470,118	1,477,270	1,450,225	7,513,035	1,583,202	1,436,348	1,574,045	1,561,400	1,649,350	7,804,345
Common Services	114,100	103,300	113,740	128,450	176,375	604,345	102,129	113,918	116,497	119,900	125,000	577,442
	<u>1,971,675</u>	<u>1,967,670</u>	<u>1,834,658</u>	<u>1,875,220</u>	<u>1,949,900</u>	<u>6,429,600</u>	<u>1,945,677</u>	<u>1,807,592</u>	<u>1,963,369</u>	<u>1,944,044</u>	<u>2,014,750</u>	<u>6,705,422</u>
<u>Renewals &amp; Rearrangements</u>												
Telegraphs	58,575	23,430	33,700	19,350	21,850	149,375	45,475	17,324	23,905	25,363	19,500	131,567
Telephones	926,395	823,550	452,650	332,500	364,215	2,708,590	613,619	496,865	319,398	305,867	271,000	2,008,749
Common Services	43,800	23,185	17,810	13,930	8,280	111,775	26,149	17,375	7,904	6,380	8,750	66,858
	<u>1,027,000</u>	<u>860,675</u>	<u>499,160</u>	<u>368,580</u>	<u>394,305</u>	<u>2,969,570</u>	<u>685,243</u>	<u>531,564</u>	<u>351,207</u>	<u>337,610</u>	<u>299,250</u>	<u>2,205,174</u>
<u>Construction</u>												
<u>Telegraph</u>												
Imperial Wireless Chain	109,000	-	-	-	-	109,000	69,988	81,421	7,869	365	30,700	190,343
Wireless Equipment	35,500	30,550	11,000	3,470	1,435	90,405	365	1,955	17,521	2,772	250	25,663
Wireless Buildings		7,450	1,400	-	-		5,251	3,276	843	-	475	9,847
Wires & Pneumatics for Cable Cos. & Newspapers	11,500	3,150	2,000	125	355	17,130	1,118	3,697	Cr. 143	Cr. 195	1,800	6,277
Teleg. Extns. & Apparatus. Pneumatic Plant &c.	37,500	32,950	25,220	23,695	25,270	149,805	29,842	18,505	Cr. 29	9,753	6,700	64,771
Main Underground	60,560	23,425	5,450	2,500	-	91,765	23,469	-	415	5,453	-	29,338
New Cable Ship (Part Cost)	3,000	44,250	33,550	52,500	18,375	149,875	2,194	10,720	34,308	14,382	24,850	116,452
Beachy Head-Havre Cable		-	-	25,000	-	25,000	-	-	-	20,808	2,100	23,008
	<u>258,880</u>	<u>141,775</u>	<u>74,220</u>	<u>107,620</u>	<u>45,335</u>	<u>525,770</u>	<u>135,227</u>	<u>119,576</u>	<u>60,783</u>	<u>63,438</u>	<u>66,875</u>	<u>465,899</u>
<u>Construction Common Services</u>	47,750	83,800	23,720	18,300	11,050	184,850	44,079	25,568	13,791	5,553	5,500	94,489
<b>Total VOTE Programme</b>	<b>3,303,365</b>	<b>2,864,165</b>	<b>2,443,955</b>	<b>2,359,310</b>	<b>2,295,930</b>	<b>13,209,590</b>	<b>2,810,236</b>	<b>2,484,598</b>	<b>2,389,140</b>	<b>2,370,645</b>	<b>2,416,375</b>	<b>12,470,984</b>
<u>War Expenditure</u>												
Civil Pay & War Bonus of or Substitution Pay for Men serving with the Colours and War Bonus of Civilians employed on Vote Programme	-	-	-	-	-	-	117,612	568,101	649,280	891,448	1,073,250	3,299,691
Emergency Circuits	-	-	-	-	-	-	380,808	363,684	697,734	929,797	785,000	3,157,023
<b>CAPITAL</b> =====												
<u>Telephone Trunks</u>												
Overhead		210,200	91,618	65,000	27,700							
Underground		497,450	143,000	74,000	28,000							
Switch equipment	1,650,000	58,650	15,000	11,500	10,775	2,932,250	1,307,656	547,225	101,180	91,284	23,900	2,071,245
Anglo-Dutch cable												
New Cable Ship (Part Cost)		14,750	11,185	17,500	5,525							
		<u>781,250</u>	<u>261,000</u>	<u>188,000</u>	<u>72,000</u>							
<u>Telephone Exchanges London</u>												
Joining up Subs. Renters &c.		71,950	41,000	17,000	34,800							
External Work &c.	550,000	197,300	43,000	30,000	7,200	1,093,700	411,128	209,983	46,077	Cr. 10,758	48,550	704,980
Internal Work &c.		48,750	33,000	21,200	Cr. 3,000							
		<u>518,500</u>	<u>119,000</u>	<u>68,200</u>	<u>40,000</u>							
<u>Telephone Exchanges Provinces</u>												
Joining up Subs. Renters &c.		179,700	118,000	30,000	51,000							
External Work &c.	1,550,000	430,400	187,800	105,800	58,000	3,048,300	1,353,018	478,738	69,174	78,619	178,650	2,174,199
Internal Work &c.		204,350	200	75,000	79,000							
Coast Communications		1,850										
		<u>518,500</u>	<u>356,000</u>	<u>211,600</u>	<u>130,000</u>							
<u>Sites &amp; Buildings</u>		135,750	40,000			175,750	141,971	90,932	30,444	10,042	1,500	274,819
<u>Post Office Railway (elec. eqpt. &amp;c)</u>	5,900	8,000	5,000	500	400	19,800	4,833	2,302	181	203	110	7,649
<u>Repairs of Services</u>	25,000	28,700	29,000	29,800	33,800	142,500	130,508	44,500	145,000	337,000	95,500	802,508
<b>Total</b>	<b>7,084,205</b>	<b>4,827,800</b>	<b>3,177,955</b>	<b>2,837,010</b>	<b>2,832,920</b>	<b>30,419,890</b>	<b>8,717,983</b>	<b>4,788,093</b>	<b>4,148,210</b>	<b>4,898,280</b>	<b>4,610,835</b>	<b>24,963,398</b>



## ENGINEERING DEPARTMENT.

## MAIN UNDERGROUND WORKS.

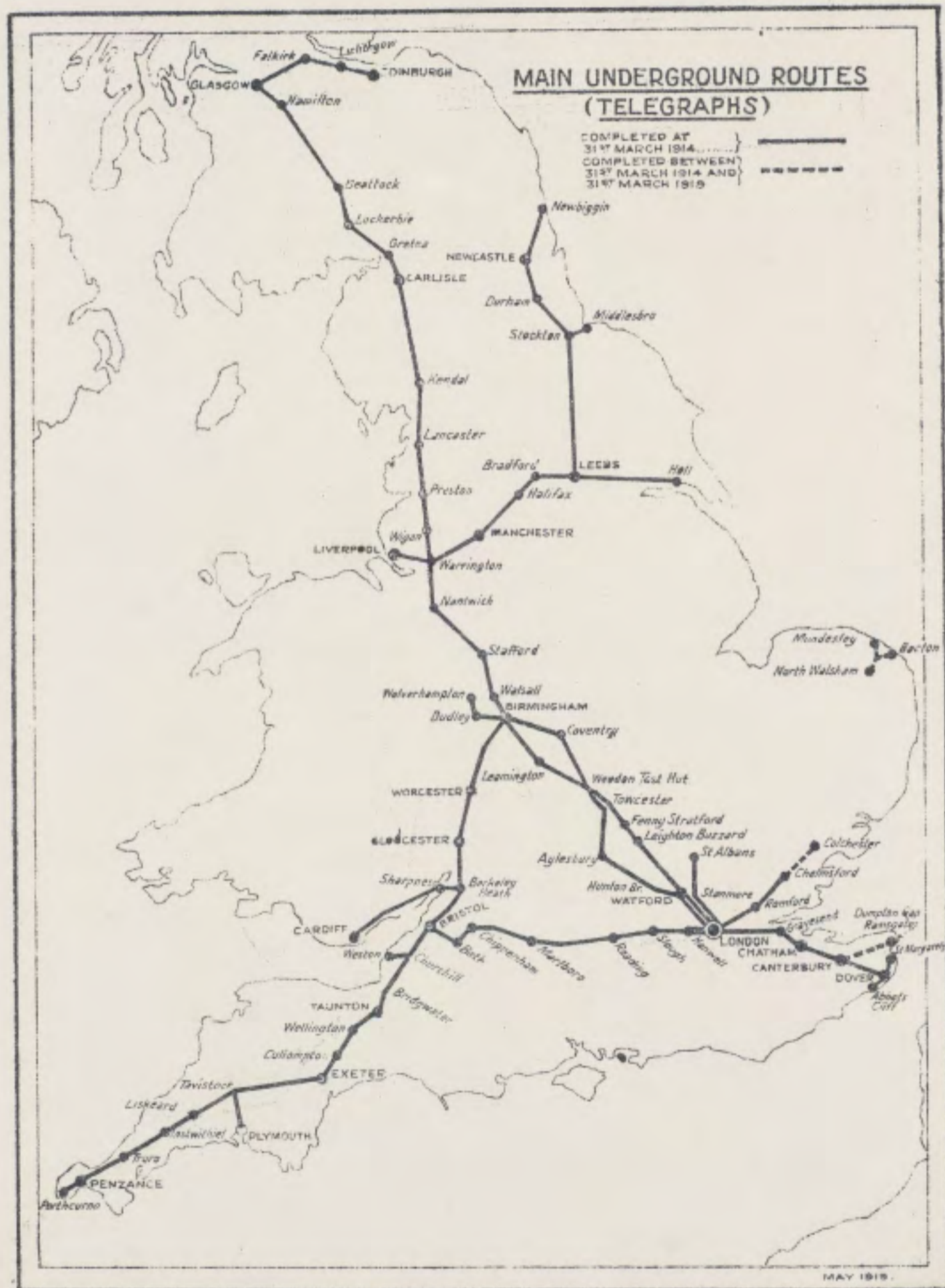
Completed between 31 March 1914 and 31 March 1919.

(All Telephone Cables except where otherwise stated).

Work	Mileage				Year completed.
	Ducts		Cable		
	Route	Single Way	Route	Circuit	
Canterbury-Ramsgate-Dumpton Gap (Telegraphs)	18 $\frac{1}{4}$	19	19 $\frac{1}{4}$	195	1914-15
London - Slough	20	60	24	4800	"
" Weybridge - Guildford	35 $\frac{3}{4}$	94	35 $\frac{3}{4}$	5125	"
Sheffield - Barnsley	11 $\frac{3}{4}$	32 $\frac{3}{4}$	13 $\frac{3}{4}$	1374	"
Manchester - Ashton	-	-	6	1200	"
" Stockport	6 $\frac{1}{2}$	26 $\frac{1}{4}$	6 $\frac{1}{2}$	1200	"
Birmingham - Walsall	9	36	9	1800	1915-16
" Wolverhampton	-	-	13 $\frac{1}{4}$	2650	"
Bolton - Blackburn	13	33	13	700	"
" Preston	20 $\frac{1}{4}$	74	20 $\frac{1}{4}$	1100	"
Cardiff - Swansea	44 $\frac{1}{4}$	144 $\frac{1}{4}$	45	4500	"
Glasgow - Paisley	7	34 $\frac{3}{4}$	7 $\frac{1}{2}$	1500	"
Guildford -Aldershot-Farnham	10 $\frac{1}{2}$	19	13 $\frac{1}{2}$	730	"
Isle of Wight, Culvers - Needles	27	27	27	190	"
Leeds - Bradford	9 $\frac{1}{4}$	33 $\frac{1}{4}$	9 $\frac{1}{2}$	2374	"
" Castleford	8	17 $\frac{1}{4}$	10 $\frac{1}{2}$	1596	"
" Dewsbury-Huddersfield	16 $\frac{1}{4}$	36 $\frac{1}{2}$	16 $\frac{3}{4}$	3738	"
Liverpool - Birmingham	86 $\frac{1}{2}$	249 $\frac{1}{2}$	89	9256	"
" St. Helens	14 $\frac{3}{4}$	94 $\frac{1}{4}$	12	1872	"
London - Birmingham	-	-	109 $\frac{1}{2}$	11388	"
" Brighton	45 $\frac{1}{2}$	202 $\frac{3}{4}$	53 $\frac{3}{4}$	5274	"
" Ware	19 $\frac{1}{2}$	73 $\frac{1}{2}$	23 $\frac{1}{2}$	4700	"
Manchester - Bolton	11	81	11	2200	"
" Bury	-	-	9	865	"
" Oldham	7	22	7 $\frac{3}{4}$	745	"
" Rochdale	10 $\frac{1}{4}$	27 $\frac{3}{4}$	11	1100	"

## APPENDIX R. (CONTD).

Work	Mileage				Year completed
	Ducts		Cable		
	Route	Single Way	Route	Circuit	
Newcastle - North Shields	7 $\frac{3}{4}$	19 $\frac{1}{4}$	8	800	1915-16
" South Shields	6 $\frac{1}{4}$	17 $\frac{1}{2}$	10	1000	"
North Walsham - Mundesley - Bacton (Telegraphs)	7 $\frac{1}{4}$	11	7 $\frac{1}{4}$	115	"
Oldham - Halifax	-	-	20	1080	"
Ormskirk - Southport	8	18	8 $\frac{2}{4}$	460	"
St. Albans - Luton	9 $\frac{1}{2}$	29	10 $\frac{3}{4}$	580	"
St. Helens - Wigan	9	19	9	865	"
Swansea - Llanelly	8 $\frac{1}{2}$	9 $\frac{1}{4}$	12	1260	"
" Port Talbot	-	-	15 $\frac{4}{4}$	1994	"
Birmingham - Coventry	-	-	18 $\frac{2}{4}$	2852	1916-17
" Sheffield	74 $\frac{2}{4}$	167	76	4105	"
Bolton - Wigan	10 $\frac{1}{4}$	27	10 $\frac{1}{4}$	985	"
Bradford - Halifax	-	-	8	1696	"
Cardiff - Newport	12	38 $\frac{3}{4}$	12 $\frac{2}{4}$	1900	"
" Pontypridd	11	31	12 $\frac{3}{4}$	690	"
Chelmsford-Colchester (Telegraphs)	11	22	24	1010	"
Ealing - Uxbridge	-	-	9	252	"
Edinburgh - Forth Bridge	5 $\frac{1}{4}$	12	8 $\frac{2}{4}$	460	"
Glasgow - Edinburgh	43 $\frac{2}{4}$	184 $\frac{3}{4}$	44 $\frac{3}{4}$	6624	"
" Kilmarnock	16 $\frac{3}{4}$	36	17	1665	"
Liverpool - Ormskirk	13 $\frac{1}{2}$	44	14	1345	"
London-Chelmsford-Colchester	11	22	54	2915	"
" Sevenoaks	21	112	25	1350	"
Manchester - Burnley	24	97	24	2064	"
" Liverpool	31	192	-	-	"
Sheffield - Doncaster	16	37	18 $\frac{2}{4}$	1000	"
Newcastle - Sunderland	7 $\frac{1}{2}$	18 $\frac{3}{4}$	12	2400	1917-18
Canterbury - Dover	15 $\frac{1}{4}$	30 $\frac{1}{2}$	15 $\frac{1}{4}$	310	1918-19
Stockport - Hazel Grove	3 $\frac{1}{4}$	6 $\frac{1}{2}$	3 $\frac{1}{4}$	78	"
Total Mileages	834	2638 $\frac{1}{2}$	1124 $\frac{1}{4}$	113927	





## APPENDIX U.

## ENGINEERING DEPARTMENT.

## 1919-20 TRUNK TELEPHONE PROGRAMME.

## MAIN UNDERGROUND WORKS.

Terminal Points of Cable	Nature of Work	Estimated Capital Expenditure.
		£
London - Manchester	Ducts and Cable	671,100
Loughborough - Nottingham	"	51,800
Derby - Nottingham	"	63,000
London - Bristol & Newport	"	551,200
Slough - Windsor	"	5,600
London - Southampton	"	279,500
London - Stanmore Corner	Cable	35,500
Sevensoaks - Tunbridge Wells	Ducts and Cable	32,600
Hull - Grimsby	"	60,000
Leeds - Harrogate	"	80,000
Leeds - Wakefield	Cable	29,800
Leeds - York	"	100,000
Liverpool - Manchester	"	99,600
Liverpool - Chester	"	31,200
Manchester - Bolton	"	33,000
Manchester - Rochdale	"	34,200
Rawtenstall - Bacup	Ducts and Cable	8,400
Ormskirk - Preston	"	49,800
Glasgow - Coatbridge	"	26,500
Coatbridge - Airdrie	"	3,300
Glasgow - Motherwell	Cable	25,700
Motherwell - Hamilton	Ducts and Cable	4,100
Motherwell - Wishaw	"	5,900
Glasgow - Dumbarton	"	42,000
Paisley - Greenock	"	63,800
	Total	£2,387,600

## ENGINEERING DEPARTMENT

## DEVELOPMENT OF LOCAL TELEPHONE SYSTEMS.

Summary of work done during the period of 1st April 1914 to 31st March 1919, excluding that carried out by Superintending Engineers under their own authority.

District	Mileage of pipe laid.						Mileage of cable drawn in					
	1914/5	1915/6	1916/7	1917/8	1918/9	Total	1914/5	1915/6	1916/7	1917/8	1918/9	Total.
London	203	80.202	20.568	7.337	3.341	314.448	268	143.956	21.891	19.929	18.116	471.892
Eastern	22	16.653	.037	.128	.787	39.603	27	29.443	1.160	.150	1.928	59.679
South Eastern	96	41.823	.485	.680	10.859	149.847	114	83.093	10.913	3.738	34.552	246.294
South Midland	85	37.098	9.808	15.263	7.346	154.315	109	70.417	13.180	21.161	16.236	229.995
South Western	37	2.700	.197	-	.090	39.987	65	9.070	.181	-	1.401	75.652
South Wales	25	5.699	2.273	.827	3.441	37.240	34	19.275	5.716	3.530	7.313	69.834
North Midland	90	2.518	.362	.074	2.137	95.091	104	25.280	1.700	1.142	5.722	137.844
North Wales	64	4.527	3.018	3.396	5.252	80.193	68	27.090	7.021	10.644	7.809	100.564
North Western	49	24.828	.542	-	1.204	75.621	58	56.708	1.027	.428	1.840	118.003
South Lancashire	98	11.173	2.007	.278	.812	112.270	145	25.683	3.237	.834	2.111	176.965
North Eastern	48	.222	1.241	.445	1.806	51.714	88	25.886	1.603	1.162	1.040	117.691
North	19	2.203	1.410	.440	10.400	33.453	38	7.755	1.524	.732	11.413	39.424
Scotland West	49	19.179	.735	.028	.861	69.803	74	31.891	2.340	.949	.755	109.935
Scotland East	44	9.120	.331	-	.902	54.353	45	18.365	.936	-	3.567	67.868
Ireland	56	24.557	.947	.165	-	81.689	70	45.336	2.513	1.122	-	118.971
Totals	985	282.500	43.761	29.059	49.238	1389.558	1307	619.248	74.942	63.520	113.891	2180.601

## ENGINEERING DEPARTMENT

## DEVELOPMENT OF LOCAL TELEPHONE SYSTEMS.

Summary of work done during the period of 1st April 1914 to 31st March 1919 excluding that carried out by Superintending Engineers under their own authority.

District	No. of Poles erected						Mileage of overhead wire erected.					
	1914/5	1915/6	1916/7	1917/8	1918/9	Total	1914/5	1915/6	1916/7	1917/8	1918/9	Total
London	180	225	62	82	30	577	173	103.962	23.562	75.949	29.918	406.391
Eastern	1364	595	103	13	133	2208	402	210.250	42.500	38.250	42.473	735.473
South Eastern	1813	631	162	67	520	3193	795	287.264	27.430	96.000	268.750	1474.444
South Midland	3224	815	15	245	221	4520	1200	563.450	29.244	105.289	213.556	2111.539
South Western	2872	476	1	-	4	3353	1086	274.000	1.998	-	4.500	1366.498
South Wales	2304	326	217	272	86	3205	624	202.740	52.469	106.264	52.576	1038.049
North Midland	2433	614	10	13	205	3275	1212	396.500	48.750	76.500	149.800	1522.550
W. Wales	1724	519	147	64	58	2512	541	130.611	15.283	90.833	40.467	819.194
North Western	1238	233	4	90	7	1572	770	255.499	68.822	32.500	50.712	1177.533
South Lancashire	721	529	77	17	3	1347	274	347.267	117.437	37.834	4.286	790.804
North Eastern	1250	212	7	14	11	1494	494	157.500	2.000	16.957	14.000	684.457
North	501	90	75	18	17	701	403	98.500	60.800	42.801	25.673	630.774
Scotland West	851	313	06	111	92	1453	510	267.250	106.000	65.500	61.750	1010.500
Scotland East	2501	369	7	40	69	2986	1190	198.304	34.750	9.297	97.884	1530.235
Ireland	634	445	115	60	3	1257	440	204.648	168.000	28.500	.568	841.716
Totals.	23610	6390	1088	1.106	1.459	33653	10,114	3697.745	799.045	816.474	1066.693	16484.157

## Appendix W.

Engineering Department

List of New Manual C.B. Exchanges opened in London  
during the period of the war.

Exchange	Capacity	
	Present	Ultimate
Greenwich No.1 C.B.	1300	3000
Museum No.1 C.B.	9720	10000
Purley No.10 C.B.	1200	2000
Romford No.12 C.B.	360	800

List of New Manual C.B. Exchanges opened in the Provinces  
during the period of the war

Exchange	Capacity	
	Present	Ultimate
Cleckheaton No.12 C.B.	300	1000
Darlaston No.12 C.B.	108	120
Devonport No.10 C.B.	700	2000
Darwen No.10 C.B.	520	1050
Dover No.10 C.B.	700	1500
Lowestoft No.12 C.B.	480	900
Leeds TK.	)00 Long Dist.) )17 Tandem )16 Toll	-
Manchester Central No.1 C.B.	7500	9500
Merthyr Tydvil No.12 C.B.	310	560
Ryde No.12 C.B.	400	540
Smethwick No.12 C.B.	300	720
Truro No.12 C.B.	260	400
Tunbridge Wells No.1 C.B.	1200	3000
Weybridge No.10 C.B.	800	1300
Wrexham No.12 C.B.	460	800
Wilmslow No.12 C.B.	320	500
Woking No.10 C.B.	600	1400
Whitehaven No.12 C.B.	200	400
Wishaw No.12 C.B.	240	400



## Appendix W (Contd.)

List of Extensions of Manual C.B. Exchanges in the Provinces during the period of the war.

Exchange	Extension Particulars
Altrincham No.1 C.B.	300 lines
Aberdeen No.1 C.B.	340 "
Aberdeen No.1 C.B.	Equipment arranged for Working Trunks
Birmingham Central No.1 C.B.	4000 lines
Birmingham Midland No.1 C.B.	480 "
Birmingham East No.10 C.B.	60 "
Bournemouth No.1 C.B.	Observation Desk
Bradford No.1 C.B.	ditto.
Bristol No.1 C.B.	1400 lines
Belfast - Generator Call & Auto Clear	1800 "
ditto. ditto.	Conversion from Single to Double clear
ditto. ditto.	Additional Trunk & Junction Equipment.
Barrow-in-Furness No.10 C.B.	Additional Battery
Derby No.1 C.B.	380 lines
Dublin Generator Call & Auto Clear	1080 "
ditto. ditto.	Additional Junction Equipment.
Edgbaston No.1 C.B.	880 lines
Greenock No.10 C.B.	440 "
Lowestoft No.12 C.B.	Meter Equipment
Manchester City No.1 C.B.	2140 lines
Manchester Trunk	Supervisor's Desk
Nelson No.10 C.B.	160 lines
North Shields	300 "
Nottingham No.1 C.B.	Additional Fuse Panel
Richmond No.1 C.B.	120 lines
Salisbury No.12 C.B.	120 lines
Sale No.12 C.B.	120 lines
Sheffield (magneto)	600 lines
Sevenoaks No.12 C.B.	100 lines
Sutton No.10 C.B.	800 lines
Tunbridge Wells No.1 C.B.	Electrophone Equipment
Worcester No.10 C.B.	320 lines
Worthing No.10 C.B.	300 "

Appendix W (Contd.)

List of Extensions of Manual C.B. Exchanges in London  
completed during the period of the war.

Exchange	Extension Particulars
Brixton No.1 C.B.	Additional Junction Sections
Brixton No.1 C.B.	1500 lines
Chiswick No.1 C.B.	1100 "
East No.1 C.B.	230 "
East Ham No.9 C.B.	100 "
Finchley No.1 C.B.	200 "
Finchley No.1 C.B.	700 "
Gerrard No.1 C.B.	32 Supervisor's Desks
Hammersmith No.1 C.B.	1100 lines
Hampstead No.1 C.B.	720 "
Kensington No.1 C.B.	3310 "
London Wall No.1 C.B.	3 Supervisor's Desks
London Wall No.1 C.B.	Modifications to Power Plant
Lee Green No.1 C.B.	200 lines
Mayfair No.1 C.B.	Monitor's Desk
North No.1 C.B.	1000 lines
North No.1 C.B.	Test Desk
Park No.1 C.B.	Monitor's Desk
Park No.1 C.B.	Main Frame Extension
Paddington No.1 C.B.	Keyless Junction working
Putney No.1 C.B.	1300 lines
Streatham No.1 C.B.	Additional Junction
Streatham No.1 C.B.	600 lines
Sydenham No.1 C.B.	1300 "
Trunk Exchange	Supervisor's Desk
Victoria No.1 C.B.	1600 lines
Victoria No.1 C.B.	Additional Battery
Wimble	
Wimbledon No.1 C.B.	1200 lines
Willesden No.1 C.B.	Information Desk
Willesden No.1 C.B.	540 lines
Walthamstow No.1 C.B.	320 "

ENGINEERING DEPARTMENT.

APPENDIX X.

SCHEDULE SHOWING POWER, LIGHTING, HEATING, &c. SERVICES AS AT 31st  
MARCH 1917.

POWER STATIONS.

Electric Generating	Number .....	7
	Capacity I.H.P.) or equivalent. ).....	7,771
Transforming & Converting	Number.....	5
	Capacity I.H.P.) or equivalent. ).....	3,150
Units delivered from P.O. Power Systems (L.T. units) from Sub-Stations in the case of the Central Power system).	)....	6,737,103
Maximum demand in K.W. ....		1,861
L.T. Units delivered from P.O. Stations which are supplied from an outside source. ....		507,594
Maximum demand in K.W. ....		234

POWER DRIVEN PNEUMATICS.

	Number .....	103
Capacity (a) Electrically ) driven B.H.P.).....		1,040
(b) Steam driven ) I.H.P. ).....		120

LIGHTING.

Offices lighted electrically	Number.....	1,055
Glow lamps installed (in 8 c.p. equivalents)		
	Metal filament .....	550,705
	Carbon .....	9,145
	Gas filled .....	32,520
Arc lamps installed .....		364

HEATING AND COOKING.

High pressure hot water heating systems .....	14
Low pressure hot water heating systems .....	363
Steam heating systems .....	7
Electric Radiators .....	77
Electric Washheaters .....	16

VENTILATING.

Electric Fans .....	573
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LIFTS, HOISTS, etc.

Electric .....	259
Hydraulic .....	18

ELECTRIC TRUCKS.

.....	5
-------	---

CONVEYORS.

Postal .....	76
Telegraph and Telephone .....	42

LETTER STAMPING MACHINES.

.....	361
-------	-----

BAG CLEANING MACHINES.

.....	11
-------	----

VACUUM CLEANERS.

.....	49
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MOTORS VARIOUS.

(Additional to those used for lifts, conveyors, stamping machines, fans and pneumatics, but excluding those used for telephone or telegraph purposes). ....	351
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APPENDIX Y.

Particulars for this Appendix will be submitted later.

ENGINEERING DEPARTMENT.

APPENDIX 2.

SOME PARTICULARS OF NEW APPARATUS DESIGNS  
PRODUCED DURING THE WAR PERIOD FOR  
DEPARTMENTAL PURPOSES.

Dial Condenser and Dial Resistance for use on long submarine cable circuits where close adjustment of balance is necessary.

Artificial cable 34 11 Miles Standard Cable, for general use in verifying the transmission efficiency of telephone apparatus where strict accuracy is not essential.

Three new types of Call Office Switchboards (Nos. 2, 3 & 4) arranged to enable the attendants at call offices to supervise the exchange connections.

Telephone Kiosks for street call offices.

Instrument Protector for subscribers offices, with sealing chambers in which lead covered twin cable can be terminated and sealed with insulating compound.

A "Clickless" type of ringing and speaking key - This key was introduced to prevent subscribers receiving a 'click' in their receiver due to manipulation of the Exchange Switchboard Keys.

Units Auxiliary Apparatus. Used in connection with the scheme for the working of minor trunk lines as junctions.

Distribution Frame for large Private Branch Exchanges.

Private Branch Exchange Switchboards.

Substation Call Meter for party line working.

Operators Head-Gear Receiver.

Supervisory Signal for Private Branch Exchanges.

New type of coin box introduced for use in connection with the A.T.M. Co's System.

Relay for the purpose of automatically checking meters during periodic tests.

Common Battery Branch Exchange Switchboards modified.

New form of Artificial cable for use in Transmission Testing.

Standard telephone exchange relay.

Four new Testers for universal <sup>emergency</sup> Switchboards.

An adjustable Rheostat for Telephonic Repeaters.

## ENGINEERING DEPARTMENT.

## TELEPHONE &amp; TELEGRAPH APPARATUS.

Value of Orders (excluding Military) placed from 1.4.1914 to 31.3.1919.

Year	Telegraphs			Telephones			Totals		Grand Totals
	Contracts	Factory Construction Orders	Totals	Contracts	Factory Construction Orders	Totals	Contracts	Factory Construction Orders	
	£	£	£	£	£	£	£	£	£
1914-15	27,369	4,539	31,908	401,862	10,827	412,689	429,231	15,366	444,597
1915-16	18,692	9,351	28,043	138,330	15,306	153,636	157,022	94,657	181,679
1916-17	14,607	10,309	24,916	104,627	4,855	109,482	119,234	15,164	134,398
1917-18	6,261	10,130	16,391	76,633	18,392	95,025	82,894	28,522	111,416
1918-19	8,419	13,949	22,368	158,990	6,446	165,436	167,409	20,395	187,804
Totals	75,348	48,278	123,626	880,442	55,826	936,268	955,790	104,104	1,059,894




## ENGINEERING DEPARTMENT.

STATEMENT SHEWING THE VALUE AND QUANTITY OF CABLE,  
WIRE, TELEGRAPH AND TELEPHONE INSTRUMENTS, ETC.,  
INSPECTED AND REPORTED UPON DURING THE PERIOD  
1.4.1914 to 31.3.1919.

		1914-15	1915-16	1916-17	1917-18	1918-19
<u>Cable &amp; covered wire</u>	Miles of cable	10,728	8,928	20,326	25,571	20,063
	Miles of conductor	375,293	185,866	77,438	111,949	168,068
	Value	£1,262,008	£893,154	£1,072,753	£1,487,342	£1,621,648
<u>Bare Wire</u>	Weight in tons	3,839	2,635	12,741	8,884	5,711
	Value	£261,852	£230,858	£816,425	£385,026	£645,072
<u>Telegraph &amp; Telephone instruments</u>	Value	£464,957	£200,872	£403,884	£806,908	£615,364
<u>Woodwork (Arms, ladders, etc.), Ironwork (pipes, bolts, etc.) etc.</u>	Value	£574,796	£176,646	£398,450	£517,003	£476,939
<u>Apparatus repaired at Stores Factories and tested by Engineer-in-Chief.</u>	Value	£210,831	£341,252	£317,623	£190,651	£250,000
TOTAL VALUE		£2,754,444	£1,755,782	£3,011,135	£3,885,932	£3,611,023



**PRINCIPAL SUBMARINE CABLES  
PROVIDED SINCE 4<sup>TH</sup> AUGUST 1914**

Existing Cable utilised in situ shown thus   
 New or Relaid Cable  do do   
*Fig. 12*