POULSEN EXPERIMENTS.

As stated on page 4 of Annual Report of Torpedo School, 1911, experiments with the Poulsen system are being carried out on a considerable scale.

Apparatus purchased for Experiments—

1 complete Poulsen transmitting set.
5 additional Poulsen arcs.
2 complete receiving sets.
3 500-volt motor generators (these have been erected at Horsea W.T. Station).

The apparatus, though essentially the same as that described in previous reports, has been considerably improved with regard to details of design and construction.

The arcs are now placed in series with the aerial instead of being inductively coupled through a shunted oscillating circuit. An ammeter in the aerial shows when the best adjustment of the arc has been obtained.

The considerations which governed the purchase of six of these arcs were that the Poulsen Company in Denmark had been unable to demonstrate successfully with any arcs above 5 k.w. It was hoped that by using a number of these arcs in series-parallel larger powers could be obtained.

At present there appears to be some difficulty in getting the arcs to burn satisfactorily in series-parallel. From information obtained, as the result of a visit by Commander Payne to the Federal Company's station at San Francisco, it appears that this company have successfully overcome the difficulties in connection with large arcs, and proposals have therefore been submitted for the purchase of two large arcs and other apparatus.

Précis of Report by Commander Payne on a Visit to the Federal Companies Stations at San Francisco.

The Federal Company control 18 stations, in all of which the Poulsen system is used. Sixteen 12-k.w. stations are used for commercial working between Chicago, Los Angeles, and Seattle; two 24-k.w. stations are used for communication between Honolulu and San Francisco.

Demonstration at 24-k.w. Station, San Francisco.—Morning programme with Honolulu commenced at 6.45 a.m., sunrise at San Francisco being at 5.56 a.m., and good communication was maintained until 7.30 a.m. when the strength of signals fell off rapidly until communication failed at 7.45 a.m. This latter time corresponded with sunrise at Honolulu.

Night programme. Very bad atmospherics prevailed, these would probably have entirely prevented communication by spark system. Portions of the first transmission were lost owing to atmospherics, second repetition received correctly.

External Equipment of Stations.—Two wooden masts 600 feet apart and 440 feet high. Aerial similar to that in use at Lyngby.

The Earthing arrangement consists of :—

(*a*) A network of wires buried 2 feet.
(*b*) Four horizontal wires suspended from the masts 180 feet above the ground and connected to the buried earth.

This balanced aerial is only used when transmitting, and is not used in the smaller stations.

Internal Equipment.—Six hundred volt 24-k.w. D.C. generator driven by a belt of a 3-phase induction motor, supplies power to the arc. Improvements in the arc consist of :—

Automatic arc striking mechanism.
Better cooling arrangements.
Stronger magnetic field.
Better insulation to electro magnet windings.

Transmitting switch controls valves for starting and stopping flow of gas or alcohol to arc chamber, operates motor for rotating carbon electrode and also motor for water-cooling service. This allows of switching over from receiving to transmitting in one second.

For high-speed working the Telegraphone is used in conjunction with three Audion magnifiers arranged in series. No silent cabinets are used and the operators habitually type the signals as they receive them in the telephones. The usual type of Poulsen vibratory tikker has been replaced by a rotary tikker; this consists of a grooved brass slip-ring mounted on the shaft of a small motor which is kept in continuous rotation during the reception of signals, a light phosphor bronze wire rests in one or the other of the grooves, and produces a rapid make and break as the wheel revolves.

Duplex Reception and Transmission.—A demonstration of duplex working was witnessed at the Los Angeles station, messages from Central Point (600 miles), and Beach Station, San Francisco (330 miles), were received simultaneously, the difference in wave-length being 7 per cent. The 24-k.w. station at San Francisco also sent two messages simultaneously, both of which were easily read; difference in wave-length about 10 per cent.

Future Experiments with long-range Installations.—The company hope shortly to have a 60-k.w. arc installed in the Honolulu and San Francisco stations, and anticipate no difficulty in maintaining constant day and night communication.

WAVEMETERS.

New Design of Wavemeter.

The first of these wavemeters which were described on page 23 of the Annual Report of 1911, W.T. Appendix, have been delivered. They are being calibrated at the National Physical Laboratory and also in "Vernon" for all Service wave-lengths. They will be issued to Flag-ships and Schools for trial.

A thermo junction in vacuo is supplied with each new wave meter. This consists of a small bulb, similar to a 4-volt lamp in appearance, and containing the thermo junction, also a holder which fits on to the galvonometer. The holder is so designed that the bulb can only be put in in one way, which ensures that the elements of the thermo junction will be joined up to the galvanometer in the right direction. Two spare bulbs are supplied with each set. An ordinary thermo junction is supplied with the set, also a spare one. The vacuum junction and the spare junction are stowed each in a small box in the drawer of the wavemeter itself.

Calibration of Wavemeters.

A large number of wavemeters have been calibrated at the National Physical Laboratory. The results of the calibrations show the inductance of each coil, and the virtual capacity of each coil, which must be added to the condenser value when not using the "Vernon's" wave-length table. They also give a curve for the condenser.

After calibration at the National Physical Laboratory all wavemeters are calibrated in "Vernon" for all service wave-lengths. A card is filled in giving the actual scale reading for all waves using two inductances for each wave, and with a mutual and with no mutual. These scale readings are always to be used when tuning to service waves; no allowances have to be made and it ensures all ships being tuned to exactly the same wave-lengths.

A large mutual, stool for mutual, and a small mutual are issued with each recalibrated wavemeter. The whole wavemeter with its inductances, mutuals, &c., form one unit, and the different parts must never be separated.

All flag ships, schools, flotilla cruisers, &c., have been supplied with the recalibrated wavemeters, and a good many private ships.

Steps are being taken to do the whole of the calibrating in "Vernon," now that the most important ships have been supplied.

Radiation Meter.

The supply to destroyers of Radiation Meters, as proposed on page 10 of last year's report has come into effect. The only difference between the radiation meter for types 1 and 2 and type 4, is that the latter has a special shunt of its own, having a single turn of copper tube in place of the bridge piece fitted to types 1 and 2. This supplies the necessary inductance to give a good scale reading.

Buzzer Repeaters.

The supply of this apparatus as proposed on page 10 of last year's report, has been carried out. Leads are carried from the W.T. office to a repeater in the distributing office, and from there to a switch which cuts in or out a repeater on the fore bridge. The order re fitting up is contained in G. and T. Order No. 61 of 1912.

Silent Cabinets.

Ventilation.—In spite of alterations in the way of reducing baffles and forcing air into the cabinet instead of drawing it out, the ventilation has still left much to be desired. It is now approved, *see* G. 15633/10, to fit a new pattern circulator, Patt. No. 2779–81, which is tested to give

a pressure of 3½ inches on a water gauge under working conditions. Stocks of Patt. Nos. 1000, 2344, 551 circulators will be exhausted by fitting two in series instead of one new pattern one.

Lead Lining.—Trials are being carried out with lead-lined cabinets. The lead is placed directly under the ply-wood lining, and extends under the floor, over the roof, and the door. The screening effect should be greatly improved. Also it is only necessary to screw through the wood lining to find an efficient earth. If experiments are successful, lead lining will be introduced generally.

Brown's Telephone Relay

With reference to last year's Annual Report, page 210, further experiments with this relay have been carried out at Horsea W.T. station.

When in adjustment the relay gives excellent results, but owing to the instability of this adjustment and to the fact that it intensifies the sound of atmospherics and local noises in the same proportion as the signals, it has been decided not to adopt the relay. (C.P.N.S. 5143/5327 of 12th March 1912.)

Emergency Set.

Ten sets, each consisting of a large size motor ignition coil and a ten-volt Exide battery have been purchased and issued to sea for trial.

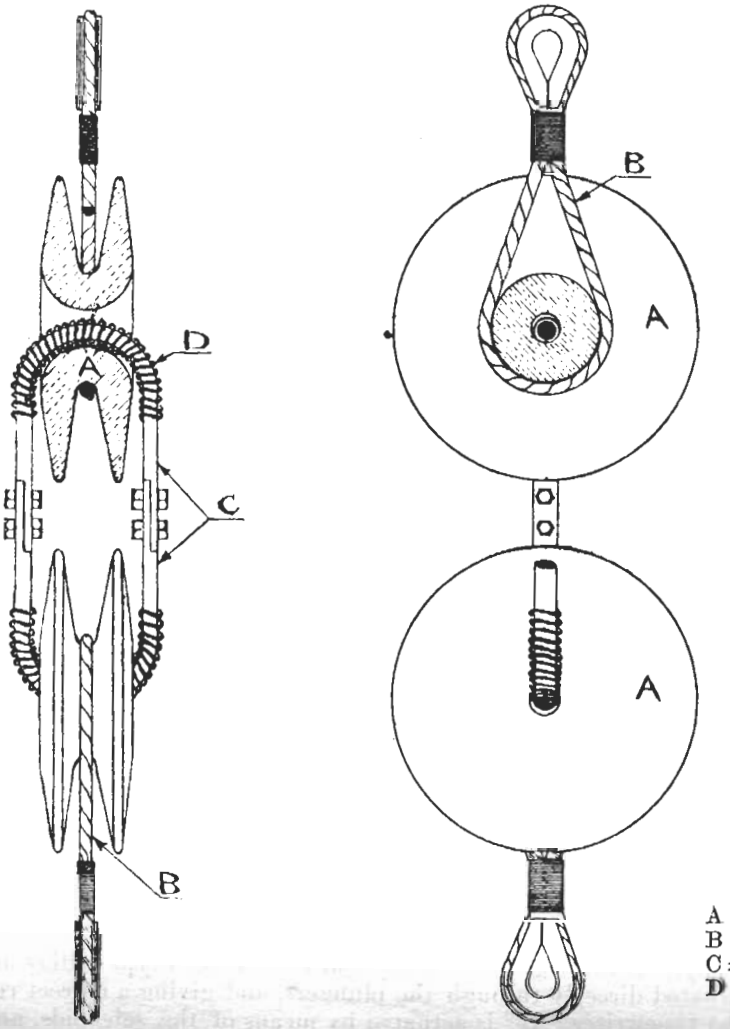
The set is intended to be used in emergency when no power is available. A simple method of doing this, is to have a small gap placed in the aerial earth lead, and normally short circuited. The coil to be kept joined up to this gap. When required for use, the short circuiting piece should be removed and the coil used to spark into the aerial "plain."

If reports on the coil are satisfactory, it will supersede the 10-inch coil Patt. No. 1784, and be used for tuning, &c. It should also be useful for boat work and for an extemporised landing set.

Rigging Insulators.

Experiments have been continued with the insulator shown in Plate 10 of last year's Appendix to Annual Report. Trouble has been experienced in getting the strain to fall all in a straight line within the insulator. Owing to the strain coming slightly crooked the porcelains are broken. A new design is being got out, which will have light tie rods in place of the metal cylinder A, it will also have no end discs G.

Another design of insulator, *see* figure, is under trial for ½-inch and ¾-inch rigging.



Reference.

A = Porcelain.
B = Steel wire grummet.
C = Steel links.
D = Flexible wire serving to give soft seating.

This pattern is easier to manufacture and passes all tests satisfactorily. It has a much longer surface than the egg-shaped insulator. It may be used for larger sizes if found superior to the other new design.

Transmitting Condensers.

It has been thought, generally, that the difference between the values of ebonite condensers at high-frequency and low-frequency was of the nature of 25 per cent. Accurate measurements have been made and this difference has been found to be only 5 per cent.

The following are the capacity values for the various service transmitting condensers :—

Mark 2	- - - - - -	Type 1, 47·7 to 50·4 jars.
Mark 1*	- - - - - -	„ 2, 17·1 „ 18 „
Destroyers	- - - - - -	„ 4, 16·2 „ 17·1 „
Short wave	- - - - - -	„ 1, 5 jars.
Short distance	- - - - - -	„ 3, 6 „
Portable	- - - - - -	„ 5, 45 „
H.D.	- - - - - -	„ 6, 11 „

Alteration to Protecting Switch Circuit.

G. and T. Order No. 140 of 1912, gave sketches of alterations to be carried out in the wiring of protecting switches used in conjunction with operating switches.

The alteration consists of tipping the back contacts of the Morse key with platinum and fitting a terminal on the ebonite base of the key and joining it to the lower back contact. The protecting switch coils, and also two 50-C.P. lamps in series with mains, are joined across the back contacts of the Morse key. With the key normal, the lamps burn through the back contacts, the protecting switch being short circuited. With the key pressed, current flows through the 50-C.P. lamps and through the protecting switch. This circuit is also being embodied in the circuit for the new operating switch.

TELETYPER OR MECHANICAL CYPHERER.

This instrument, due originally to Commander R. M. Groves, has been worked out in detail on "Vernon" during the year, and a preliminary model made. It is an instrument enabling a message to be automatically coded by a simple transposition of the letters or enabling such a coded message to be automatically decoded. The name "Mechanical Cypherer," under which name the instrument has, up to the present, been known, therefore explains its function, and for this reason it is proposed, in future, to refer to it as the "Teletyper," in order that the makers of the parts shall not understand their nature more than can be avoided.

The first model made has given good results, and working drawings are now being prepared with a view to ordering 10 or 12 of these machines, so that a thorough trial may be given them at sea. Referring to the Plates Nos. VI. and VII., the apparatus consists essentially of two ordinary Service typewriters "A" and "B" (*see* Plate VI.), these machines being mounted side by side on a suitable base board and having their rollers connected together by a suitable coupling "O." The ratchet mechanism which controls the movement of the roller in the horizontal plane, is removed from typewriter "B," so that the two rollers on "A" and "B" act as one, and their movement is controlled solely by the mechanism on typewriter "A." Over the keyboard of typewriter "A," which may be referred to as the "primary" typewriter, a bank of 26 plunger switches is arranged, the tops of these 26 switches forming a second keyboard corresponding exactly to the typewriter keyboard itself, whilst the bottoms rest upon the ordinary typewriter keys. One of these plungers or primary switches is shown by "T" in Plate VII., and it will be seen that this consists simply of a phosphor-bronze spring carrying a roller contact, which contact rests on red fibre when the switch is at rest, but when it is depressed makes contact with the brass plunger, and so completes an electrical circuit. The operation of depressing any one of the primary switches therefore not only depresses the corresponding key on the typewriter switchboard, but also completes a particular electrical circuit. The 26 wires from this bank of switches are led by means of a 26-core cable "N" through an interconnecting board containing parts "E" and "F," which will be referred to later, to a bank of solenoids "D" which is mounted over the keyboard of the secondary typewriter "B." A sectional view through one of these solenoids is shown by "R" on Plate VII., from which it will be seen that inside the solenoid a steel armature "S" is mounted on a spring and fitted at its lower end with a brass plunger carrying a red fibre tip. When therefore the current is passed through this solenoid the steel armature "S" is attracted downwards and the finger depresses that particular typewriter key which is underneath and in contact with it.

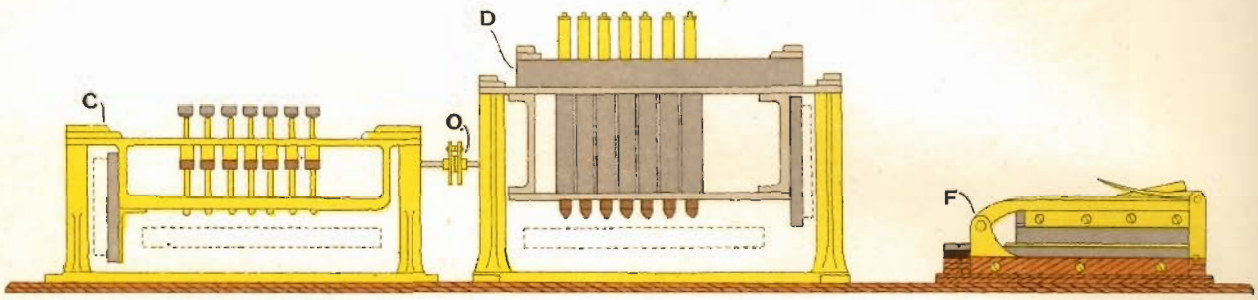
Thus, as the operator types a message on the keyboard "C" both typewriters are actuated, typewriter "A" being actuated directly through the plungers, and giving a correct record of the message being typed, whilst typewriter "B" is actuated by means of the solenoids, and therefore

TELETYPER

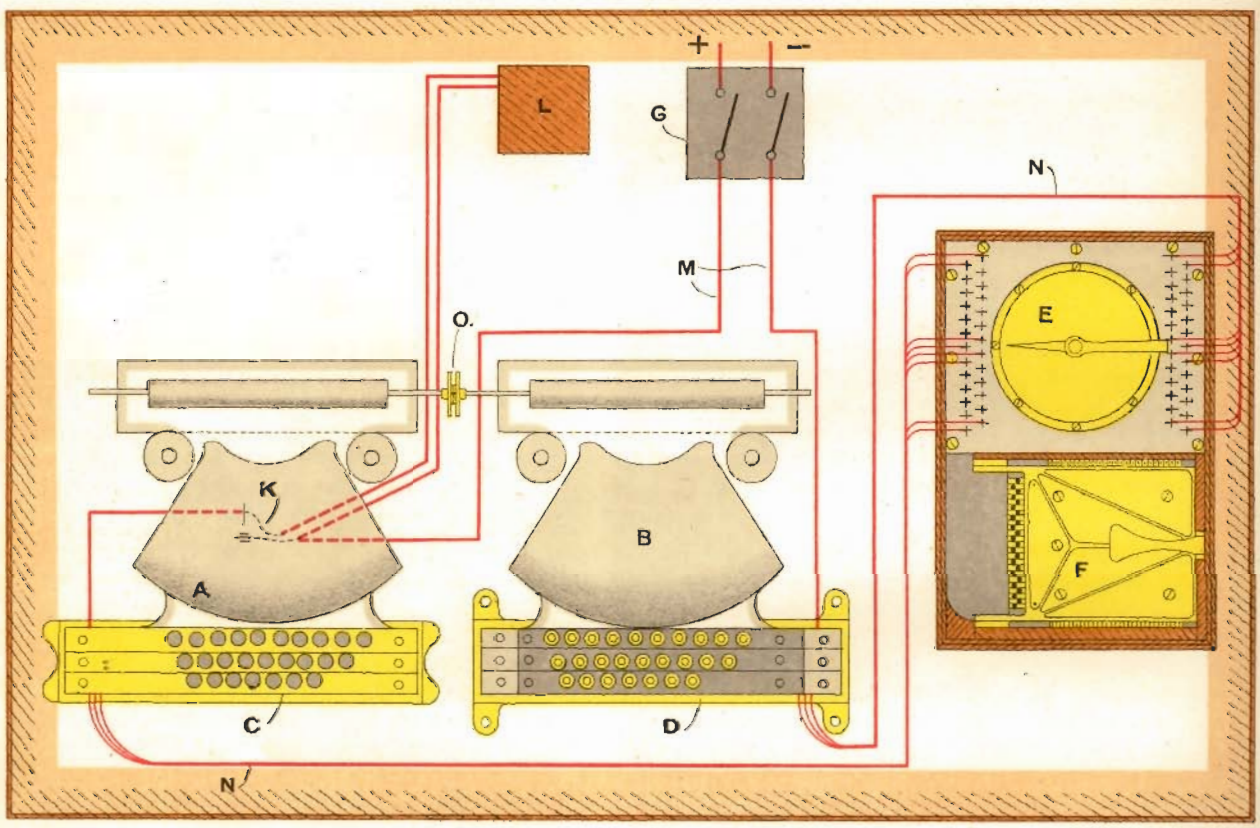
OR

MECHANICAL CYPHERER

ELEVATION.



PLAN.

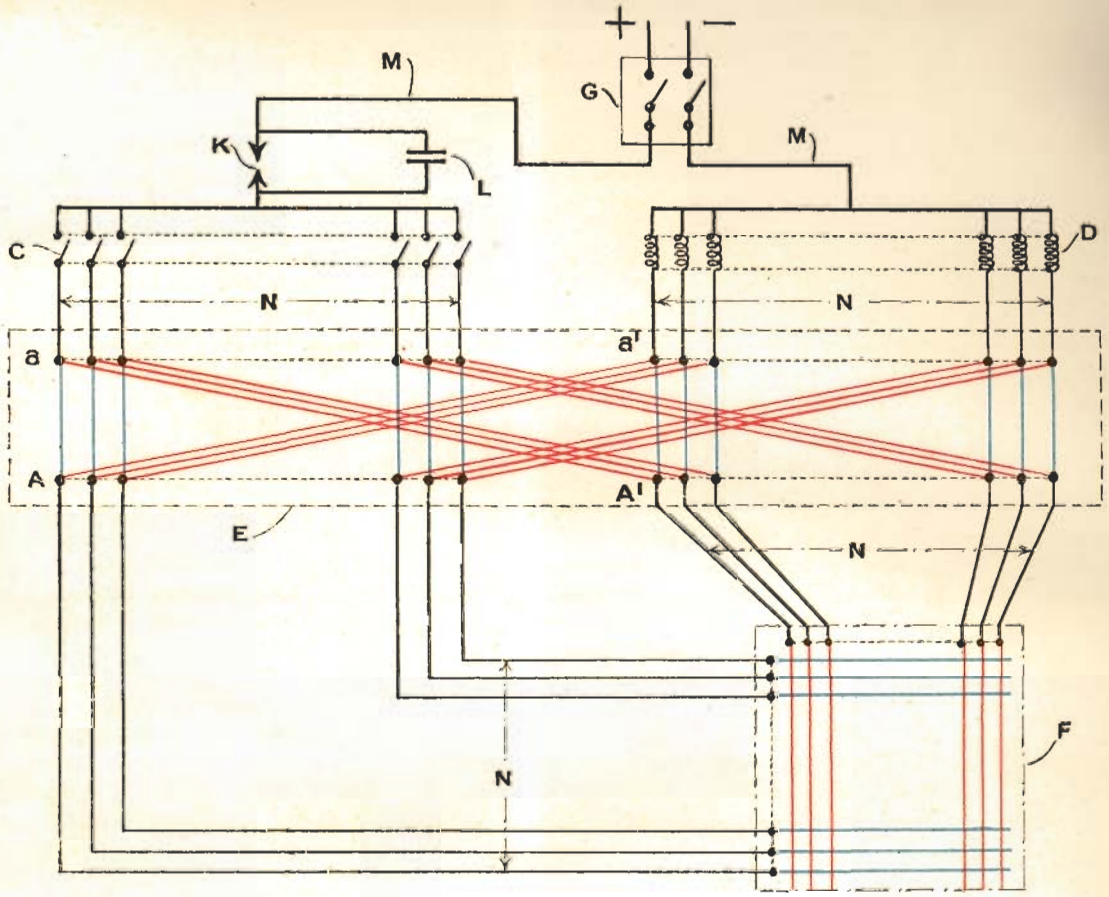


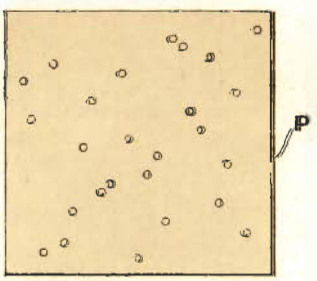
REFERENCE

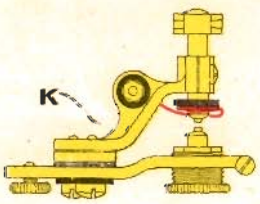
A	PRIMARY TYPEWRITER	G	SUPPLY SWITCH AND FUSES
B	SECONDARY TYPEWRITER	K	AUXILIARY SWITCH
C	PRIMARY SWITCHES	L	CONDENSER
D	SECONDARY SOLENOIDS	M	SINGLE CORE CABLE
E	CHANGE-OVER SWITCH	N	26 :-CORE CABLE
F	CARD SWITCHBOARD	O	COUPLING

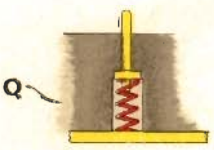
TELETYPER

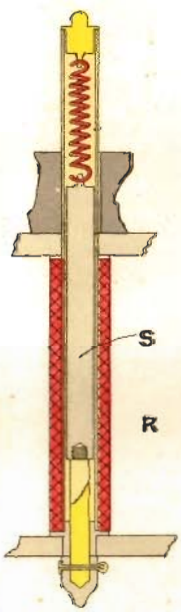
WIRING DIAGRAM & DETAILS.

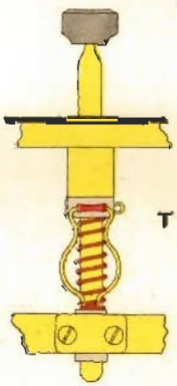












REFERENCE

C	PRIMARY SWITCHES
D	SECONDARY SOLENOIDS
E	CHANGE-OVER SWITCH
F	CARD SWITCHBOARD
G	SUPPLY SWITCH AND FUSES
K	AUXILIARY SWITCH
L	CONDENSER
M	SINGLE CORE CABLE
N	26-CORE CABLE
P	CODE CARD
Q	SPRING PLUNGER
R	SOLENOID
S	STEEL ARMATURE
T	PRIMARY SWITCH

types a coded message, the particular code depending upon the electrical connections in the parts "E" and F." In decoding a message, the message as received is typed on the keyboard "C" so that typewriter "A" gives a record of the coded message as received, whilst typewriter "B" gives the decoded message. The arrangement of electrical connections to obtain this result is referred to later.

One of the principal difficulties in the construction of the apparatus was in overcoming troubles due to sparking at the primary switches. This was eventually overcome by fitting an auxiliary switch "K" underneath typewriter "A." This switch is shown in detail on Plate VII., from which it will be seen to consist of two contacts, the upper one being mounted on, but insulated from, a small plunger, whilst the lower one is fitted in a spring box similar to the spring contact in a lamp socket. The plunger carrying the upper contact is fitted with a jaw which can be made to engage with one of the levers under the typewriter, so that every time the typewriter is operated this lever depresses the plunger and makes contact. This auxiliary switch "K" is connected in the main lead to the bank of primary switches, and a condenser "L" is connected across it. The adjustments are so made that on depressing any one of the keys the corresponding primary switch first "makes" and immediately afterwards this auxiliary switch "makes," thus completing the circuit through one of the solenoids. On releasing the key this auxiliary switch breaks the circuit, the spark being absorbed in the condenser, while immediately after this the primary switch breaks, so that this latter switch never breaks the circuit whilst current is passing.

The scheme of connections is made plain on the diagram in Plate VII. Following this out from the positive main it will be seen that the current passes through the single core cable "M" to the auxiliary switch "K," and from this switch to a wire which is common to all the 26 primary switches "C." The current then passes on by whichever primary switch is "made" along one of the wires of a 26-core cable "N" to a change-over switch "E." When this switch is in its "Code" position the connections are by the vertical lines as shown in blue, but when the switch is turned to "Decode" position the connections are as shown by the diagonal lines in red. Assuming the switch to be in the "Code" position the current passes through this switch by one of the blue lines, and by means of one core of the 26-core cable "N" to the card switchboard "F." This switchboard is of the "gridiron" type and consists of 26 parallel bus-bars underneath and insulated from another row of 26 parallel bus-bars which are at right-angles to the first set. By means of spring plunger contacts, as shown at "Q," any one bus-bar may be connected to any other so that the current passes to one of the 26 solenoids "D" the particular solenoid it reaches depending upon the connections in the card switchboard "F." Between the two sets of bus-bars in this card switchboard are arranged 26 times 26 (*i.e.*, 676) small spring plungers, but only 26 of these are in use at any one time, so that any one bus-bar is only connected to one bus-bar in the other group. To allow of the connections desired and to prevent the other plungers from making contact, cards about 5 inches square are used, each card having 26 holes punched in it, as shown at "P." One of these cards can be introduced between the two rows of bus-bars so that only those 26 plungers which lie underneath the 26 holes can make contact with the upper set of bus-bars, all the other plungers being prevented from making contact by the card.

The transposed code, therefore, depends entirely upon the arrangement of the holes in the card, and since each card may be used in eight different positions (four on one face and four on the reversed face) eight separate and different codes can be obtained with each card. It would be an easy matter to supply a box of code cards containing, say, 200, different cards, thus enabling anyone of 1,600 different codes to be used at will. In fact, many thousands of different code cards could be worked out, each giving eight different codes, provided that any symmetrical arrangement of the holes be avoided.

It was assumed in following up the electrical circuit in the above paragraph that the current would pass from one of the primary switches along the blue line of the change-over switch to the blue horizontal line in the card switchboard "F." From this it would pass to one of the red vertical lines in "F" and away to one of the solenoids "D." If the apparatus is used to code a message with the connections arranged in this way, then, in order to decode the same message, all that is necessary is to arrange that the current shall pass through the card switchboard "F" in the reverse direction to what it did before. Thus, if when coding the letter "A" on the primary it became "Z" on the secondary typewriter, when decoding the letter "Z" would become "A." This reversing can be carried out in one or two ways: (1) the card itself can be removed after the message has been coded and put in place in the reverse manner for decoding; or (2) a change-over switch "E" can be used. In fact, this change-over switch is supplied solely for this purpose in order to avoid the necessity of changing the code-card between coding and decoding messages.

The objection has been raised to an apparatus of this kind using a simple transposed letter code that it is fairly easy for an expert to decipher such a coded message, provided the message is of sufficient length. It is not considered, however, that this objection is very serious as applied to the present apparatus, owing to the ease with which the code can be changed by changing the code card, and to the unlimited number of codes available. In practice it could be arranged for the code card to be changed at stated and frequent intervals, or, as an alternative, the number of the code card used could be quoted at the beginning of each message. Owing to the large number of different combinations available, it would be possible to issue complete sets of new code cards from time to time, especially if it was feared that any of the cards had been stolen.

However, to meet the above objection an accessory, which is called a "Transposition Device," was made and tested in "Vernon"; this device being arranged to alter the code after every letter

in the message. The device consisted of a long straight commutator arranged like a small piano keyboard at the back of typewriter "A," whilst a small contact box containing 26 contacts, was arranged to slide over this fixed commutator, the contact box being coupled to the typewriter carriage so as to slide with it. Thus, as the typewriter carriage moved on after each letter the contact box also moved on and altered the connections, and therefore changed the code. Experiments with this apparatus have been carried out sufficiently far to show that it could be developed if required, but it would necessarily be a somewhat complicated and intricate device liable to give trouble in practical use, and it has, therefore, been decided for the present not to proceed with this accessory, particularly in view of the fact already mentioned that it is very doubtful whether it is necessary.

Apart from the fact of the easy changing of the code, the advantage of such a machine lies in greatly reducing the time required for coding or decoding a long message.

Since, however, each word is fully spelt, the ether is occupied by the wireless transmission of the message for a longer time than if the three-letter code were in use.