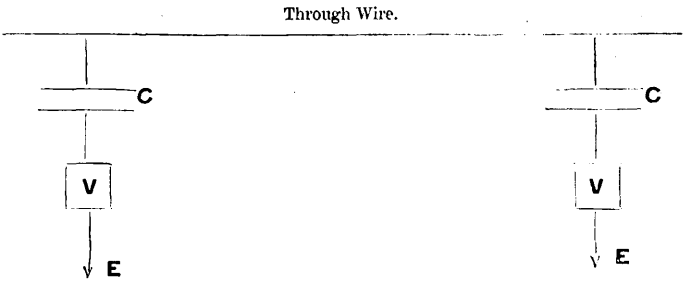
from the circuit, as also should the vibrator from the receiving end. To effect this twofold purpose a special form of signalling key (designed by the writer) is requisite, and should be used. The action of this key, together with the complete set of connections for a parallel cable crossing, is shown in Fig. 4.

Major CARDEW, R.E.: Mr. Melhuish's paper is a very interesting one to me, and I am glad to see that the course adopted by the R.E. Committee some years ago of sending some of my vibration instruments to the Government of India, is bearing such good fruit. Mr. Melhuish speaks of my vibrating sounder; but I always prefer to speak of the system of telegraphy in which that is used for transmitting and the telephone for receiving, as what I can claim. The component parts, or something approaching them, existed before, and I merely put them together and modified them as stated in my paper read before this Society in 1886. The system has certainly proved of value, not only for military lines, which are necessarily hastily constructed, but in various emergencies in our own postal telegraph system—especially after the great snowstorm a few years ago, when nearly all the lines in the country were down. Major Cardew.

The idea of effecting communication by means of two bare wires is certainly a good one, and probably even better results would be obtained with copper wires. In some cases, perhaps, a sufficient length of ordinary insulated leading-in wire could be readily obtained; and however good a system may be, it will probably work better for a little insulation.

As regards making use of the armouring of the cables to form a local circuit, this can be done even with only one cable crossing the river, for ordinary-sized rivers. I may also mention that it is easy to superimpose such local circuits on any part of a through wire without affecting the through working. It is only necessary to hook on small condensers—$\frac{1}{10}$ M.F. does well—and vibrators thus—

Major Cardew.



With reference to Mr. Melhuish's ingenious key, I may mention that in all patterns, I think, of my vibrating sounders the sounder coils are cut out of circuit at the receiving end by the back stop of the ordinary Morse key; and that in some patterns a small key is provided at the side of the ordinary key, which can be pressed by one finger when it is desired to cut out the telephone at the receiving end.*

Major-Gen. Webber.

Major-General WEBBER: The question Mr. Melhuish has brought before the meeting this night is one which, as Major Cardew has said, is a very interesting proof that while telegraphists in Europe have been pursuing this subject for some years, those who are working the telegraph system in India have also been putting it to practical use. Mr. Melhuish has referred to the question of the life of cables crossing rivers—a practical point in the working of telegraphs. In India he has had to deal with lines which belong to the permanent system of the country, and the even temporary interruption of these would cause great practical inconvenience, and therefore he has tried to find out some means of meeting such an emergency in the way he has described.

But it must not be supposed that temporary cables have not or cannot be used to great advantage, and during a considerable period, when it is necessary to obtain such a substitute. I do not think it has been mentioned in this Institution before, that temporary cables have been used in the beds of our rivers and streams. I remember, during the French War of 1870, when the Post Office was extremely anxious to effect communication with

* See diagrams B and D in my paper of May 27th, 1886 (Journal, vol. xv., p. 316).

Major-Gen Webber.

France by means of the cable which was then newly laid down from Beachy Head, that the completion of the land line to that point was a matter of great importance. It was of comparatively easy construction as far as Bromley, but from Bromley to London, in consequence of the opposition of proprietors and the road authorities, it was impossible to complete the communication in time. A cable was therefore laid in one night along the bed of the little Ravensbourne stream for five miles, which worked perfectly well, with four conductors inside it, for some weeks, until other means were available. I can quite understand that Mr. Melhuish has encountered many difficulties in the beds of Indian rivers, where the depth alters in one season from 5 feet to 50 feet or 60 feet. Of course under conditions like that cables may soon become useless.

I may also mention a case in connection with the Nile Expedition. Between Egypt and the Soudan the telegraph line is constructed on the west side of the river, but most of the "stations" and "posts" of the line of communication were on the east bank. The consequence was that the delivery of messages would have had to be by boat or by some other means, which would cause fatal delay. At the commencement, the communication was made across the river at Wady Halfa by two lengths of ordinary field telegraph cable. That loop worked well for from three weeks to a month, until replaced by two pieces of armoured cable, which worked perfectly during the remainder of the expedition.

The idea of using Cardew's vibrating sounders as described in the paper is not at all a new one in Europe. One of the most interesting experiments with them that I have come across has been already described here; it was carried out about nine or ten years ago in the Solent.

Major Cardew has also referred to what Mr. Melhuish describes as a means of maintaining communication when the insulation of the land conductor is diminished in various ways. An example to which I will allude occurred in the Soudan. It was a case of almost dead earth on an overhead line, and no communication could be maintained by any means; and it was not known

Major-Gen. Webber.

whether the line had been cut or not. The lineman—who was one of the Royal Engineers of the Field Telegraph Battalion—accompanied by an Arab, was ordered to ride along the line on his camel, and, wherever he could obtain satisfactory earth, make connection between line and earth through his telephone. A vibrating sounder was meantime placed in circuit at the station whence the lineman had started on his journey, and calls sent to line from time to time by it, as well as by means of the ordinary telegraph key. The man proceeded along the line, and, wherever he could, made his connection, and listened for the signals, which, so long as the interruption continued, were recognised by him as from the vibrator as well as from the Morse key. I remember, in this particular case, he slept in a native village, and next morning again made his connection at the same place, when, finding that the signals from the vibrator had ceased, and the circuit in full work, he came home—about 40 or 50 miles—concluding that it had been repaired by somebody else, which actually proved to have been the case.

The example which Mr. Melhuish gives here of using the armoured covering of a cable under water as a secondary line, or for diplexing the line, is an example of what Major Cardew describes, but is also one of what has been done before—and done, I believe, under similar conditions—by Van Rysselberghe, and by Mr. Langdon Davies, Monsieur Mercadier, and others. I imagine, in Mr. Melhuish's case, the armoured covering and the conductor were no longer insulated from one another, and that his vibrating communication, under conditions when insulation resistance had almost disappeared, was identical with the results obtained in the researches of those to whom I have referred. The allusion to it has led me to hope that the subject of obtaining alternative circuits from the same conductor may be discussed here at an early date.

Mr. Bright.

Mr. CHARLES BRIGHT: The interest and importance of such experiments as those carried out by Mr. Melhuish, Major Cardew, and others, are not entirely confined to telegraphy across broad rivers as met with in India and other countries (where, owing to their breadth, an aerial span is impracticable,

and where also a subaqueous line, for purposes of longevity, is often unsuited), but have, in addition, I venture to think, a considerable bearing on the problem of telegraphic communication between lightships and the shore. This is a problem which so far has not met with any very satisfactory solution, I think. Mr Bright

Experience has shown that where an ordinary existing type of submarine cable is employed, constant friction is likely to take place between the cable and the moorings of the lightship, resulting in the gradual abrasion of one or other, or of both; besides the lightship moorings getting entangled with the cable at different parts by changes of tide and currents thus causing frequent kinks and chafing in both. Various devices have been made and tried, with a view to overcoming these difficulties, in the form of the cable and of the moorings, as well as in the arrangement of the moorings; but none of these have, I fancy, been quite crowned with that success which might have been expected of them. If, however, we could signal across the water between such distances without any cable whatever, an entire solution of the problem would be arrived at.

It is to be regretted that our esteemed Past-President Mr. Willoughby Smith is not with us to-night. I think it was in 1888 that he carried out some very interesting experiments in the direction of electro-telegraphy without wires, which he communicated at the time to *The Electrician*, I believe.

Mr. Willoughby Smith, in his experiments, appears to have realised all that he had anticipated. I do not know (from what I can gather from the paper just read) whether this quite equally applies in a practical way to Mr. Melhuish's corresponding experiments of having no metallic connection between the points of communication.

In Mr. Smith's experiments, he had a wooden boat moored out some distance from shore. The shore station consisted of a wooden hut on a sandy beach, in which he had a battery of a few cells connected to a Morse key, or a double-action key,

Mr. Bright. working on two plates of different metals each yielding their peculiar sounds when pressed on. A tuning-fork and telephone completed the instruments employed; the telephone being chosen as the receiving instrument, presumably, on account of its mechanical simplicity and its extreme sensitiveness to small electrical currents. From the sending station there were two branch insulated copper wires of about 100 fathoms, each led out to the bed of the sea, where their ends were each made fast to anchors about 100 fathoms apart in a north and south direction. The boat was about midway between the two ends of the cable, and had a copper plate hanging from the bows and from the stern into the water, about 10 fathoms apart, making each plate about 45 fathoms from its nearest cable end.

A corresponding key and telephone were used on the boat attached to the plates lowered in the water. Satisfactory communication was carried out between the boat and the shore; and I am at a loss to understand why these valuable investigations on the part of Mr. Willoughby Smith have led (so far as I know) to no further experiments adapted to practical telegraphy between lightships and the shore, as it would seem to be such a complete solution of the difficulty, if perfected for the required purpose, with certain limited distances.

It is, perhaps, worthy of comment that whereas Mr. Melhuish appears to have used the Cardew vibrator, Mr. Willoughby Smith employed a telephone—the more sensitive instrument, just as it is also more sensitive than the Thomson mirror instrument.

Mr. Granville. Mr. W. P. GRANVILLE: Without wishing to detract in any way from the value of Mr. Melhuish's system—which he has proved to be of practical importance—I should like to point out that a patent was obtained in 1853 by G. E. Dering for telegraphing across seas by means of uninsulated wires, and by a plan almost identical with that described to-night, but, of course, without the aid of vibrating sounders. That is to say, two parallel uninsulated wires were to be used, the wires being separated by a considerable distance, and the ends on each shore to be connected so as to form a huge parallelogram. I

believe an actual experiment was made, but it failed, the distance being enormously greater than that practicable with such an arrangement. Mr. Granville.

With regard to Mr. Willoughby Smith's experiments, referred to by Mr. Bright, I assisted him while those experiments were being made, and can state that they were perfectly successful. Two insulated wires were laid out. Starting from a bathing hut on the beach, they were submerged at an angle to each other so as to form a V, and each sea end was metallically connected to a small iron anchor and dropped in about six fathoms of water, the two anchors being about a quarter of a mile from shore, and about the same distance apart. A rowing boat was then moored midway between the two anchors, and from each end of the boat a copper plate was suspended in the water by means of a short length of wire, and, in the boat, the ends of the two wires were connected to a telephone of low resistance—about 5 ohms. The two ends of the wires in the bathing hut on shore were joined in circuit with a battery and automatic tuning-fork contact-maker, and then, by means of a Morse key, that short-circuited the tuning-fork, signals were sent in the Morse alphabet and readily received on the telephone in the boat; the explanation being that the two plates suspended from the boat, with their connecting wires and telephone, formed a shunt circuit to the sea, intercepting an extremely small percentage of the vibratory electric current flowing through the salt water from one anchor to the other—the vibratory electric current being, of course, produced by the tuning-fork contact-maker on shore. Readable signals were also sent from the boat and received on shore.

Mr. F. Wyles: I do not feel surprised at the success Mr. Melhuish has obtained. It is some seven or eight years since I have had actual experience in the working of Major Cardew's sounder, but even at that time it was not so much a question what one could work through, but rather what one could *not* work through. The key appears to be rather complicated, and I certainly agree with Major Cardew that the key he had then in use was very much simpler than the present one. Mr. Wyles.

Mr. Mordey. Mr. W. M. MORDEY: The other day I was told by Mr. Preece that one of the effects of the experiments at Deptford was, that at Paris the sound of the alternator was distinctly heard on the telephones. This appears to indicate the possibility of telegraphing not only across rivers, but across seas, without cable connection. It is probable that the effect in this case was due to a leakage which amounted to very little, expressed in power. To get effects similar in magnitude, therefore, it would not be necessary to establish a Deptford station, but only to provide means whereby the same amount of disturbance could be caused, and to arrange for the interruption of the disturbance according to some signalling code.

The President. The PRESIDENT: As Mr. Melhuish is absent, we cannot have the pleasure of hearing a reply from him now, although on his arrival in England he will doubtless communicate to the Secretary anything he may wish to say in answer to those who have spoken; and it only remains for me to move a hearty vote of thanks to him for the interesting communication which he has forwarded to us.

The motion was carried unanimously.

Mr. Melhuish. Mr. MELHUISH, in reply [*communicated*]: All rivers of *ordinary* width in India are crossed by means of aerial spans; but the rivers which form the subject of my paper are most of them from two to seven miles in width, and are therefore of extraordinary size. To be able to signal commercial messages across rivers of this width in a successful manner without an insulated conductor, you must have, according to my experience, a *complete metallic loop*. And it is almost essential that such a loop should be provided beforehand, to be always in readiness—that is to say, during the driest season of the year, when the rivers are at their lowest—because the time comes round every year when it is extremely hazardous to attempt to lay even bare iron wire across an Indian river: this is in the flood season, July to November, when the immense volumes of water rush onward with destructive force. We have not yet laid cables containing multiple conductors in India, but a separate cable is given to each wire; and as most of the main lines consist of two or more