The fullerphone

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A historical and technical description of a Service signal instrument, invented in 1915 by Captain A.C. Fuller and still in use during and after WW2.

1915... two large armies were densely packed in their trenches, at places only a few hundred yards apart. Signal communication was mainly by telephone and various buzzer telegraph instruments, connected via single cable and earth return. The earth was thus alive with buzzer and telephone induction.

During mid-1915 the Germans were extraordinarily well informed of Allied plans. Carefully planned raids were met by hostile fire exactly timed and directed. Relieving troops would be greeted, if not by shells, by shouts of welcome from the opposing trenches.

On one occasion a Scottish battalion took over its new front to the strains of its regimental march played by a German cornet! Espionage was suspected but an interned British civilian brought back the information that induction of cables led to widespread interception of signals.

Experiments carried out within the Allied lines left no doubt of the cause of the leakage, and measures against eavesdropping were hastily introduced by using metallic circuits (two twisted wires), instead of an earth return,

within 4000 yards of the front-line.

The solution to the problem came toward the end of 1915 when Captain (later Major General) A.C. Fuller invented the Fullerphone, a small direct current Morse telegraph instrument. In October 1915, Fuller brought two prototypes to 5 Corps in Flanders. His invention was tested on a five mile loop of cable, part of which ran in the water-filled moat of Ypres, with a 10 ohm leak to earth. The instruments worked well and were obviously the answer to the problem of interception by induction which had brought the BEF signals system almost to a standstill.

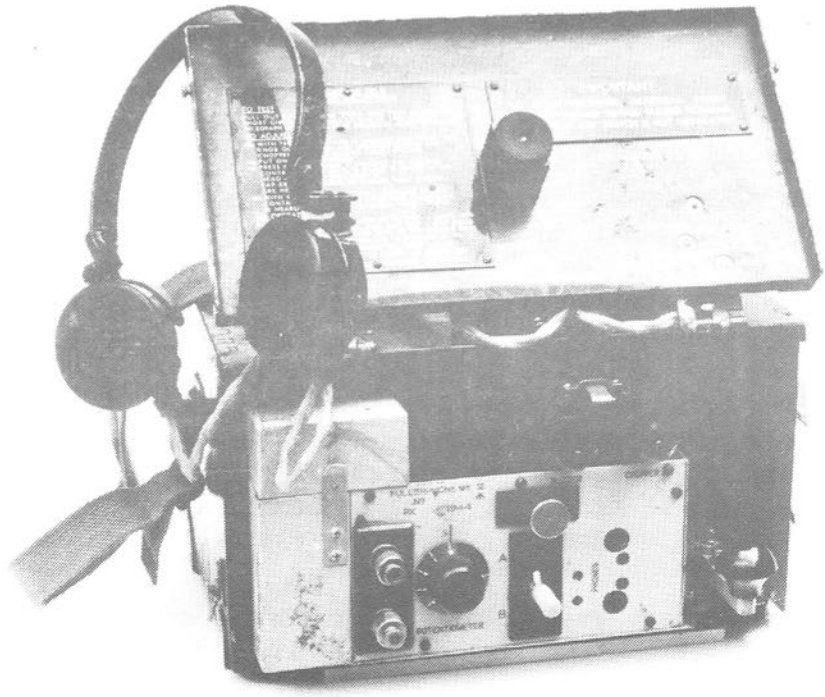

Fig. 1. Fullerphone MkV, tropicalised version of the WW2 standard instrument. The control panel carries the line terminals, potentiometer control knob, reversing switch, and phone sockets. The Morse key is mounted at the bottom right-hand side of the unit. The buzzer-interrupter (chopper) unit slides into position on the top right-hand side.

Break-in possible

The Fullerphone is essentially a d.c. Morse telegraph instrument with high sensitivity. Morse signals can be sent and received by the same instrument; no send-receive switch is used, so 'break-in' working is possible. When sending, a very small direct current will flow through the line and the receiving instrument. A readable signal will be produced with a line current of only 0.5 microamp. For reliable communication, however, a current of 2.5 microamp is considered essential.

To make the d.c. Morse signals audible, Fuller added an interrupter device to change the steady current into an intermittent current suitable for producing a note in the headphones. He completed the circuit by inserting capacitors and l.f. chokes to keep the current in the line constant as long as the key is down. The current from the sending battery passes through the sending operator's 'phones, enabling him to hear his own buzzer signals and to judge the strength of signals to the line.

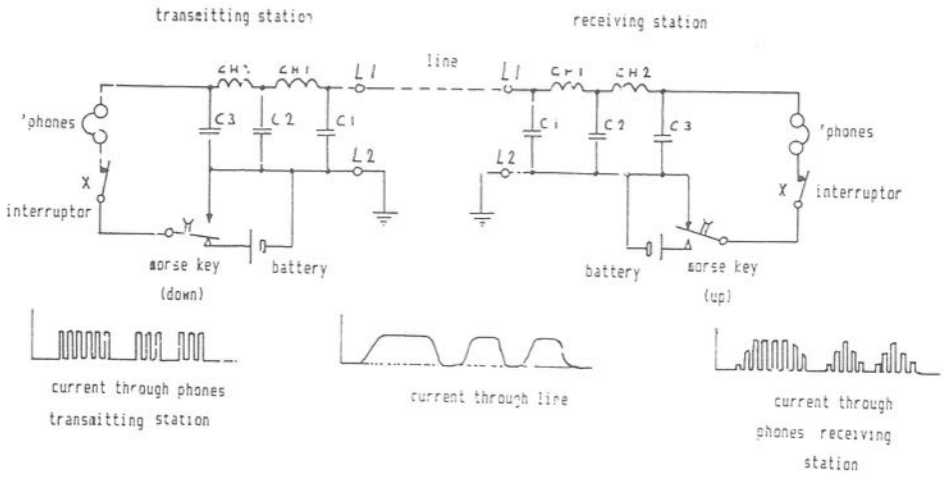

Fig. 2. Simplified diagram of Fullerphone circuit.

Should the line be cut or the distant operator's interrupter go out of adjustment, he is immediately notified by hearing musical clicks instead of his own

buzzer signals. Should his own interrupter go out of adjustment, he will hear nothing at all.

The arrangement of chokes and condensers not only prevents any appreciable variation in the line current, but also prevents any l.f. currents (such as produced by induction from other circuits) from passing through

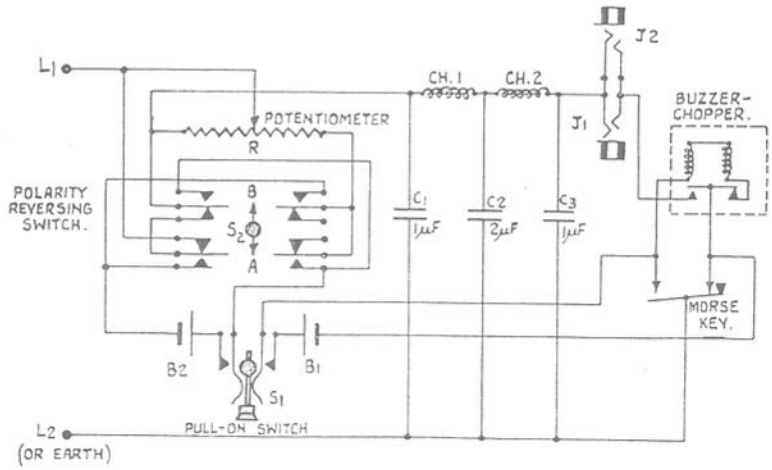

Fig. 3. Circuit diagram of Mk IV Fullerphone (1939).

the operator's headphones.

The effect of the capacitors and self-inductance of the coils also prevents the possibility of Morse signals being read from clicks by the enemy, or clicks interfering with telephony carried over the line simultaneously with Morse signalling.

Fullerphone signals cannot be overheard by induction or earth leakage, and can only be tapped by the direct connection of a similar instrument to the line. Working

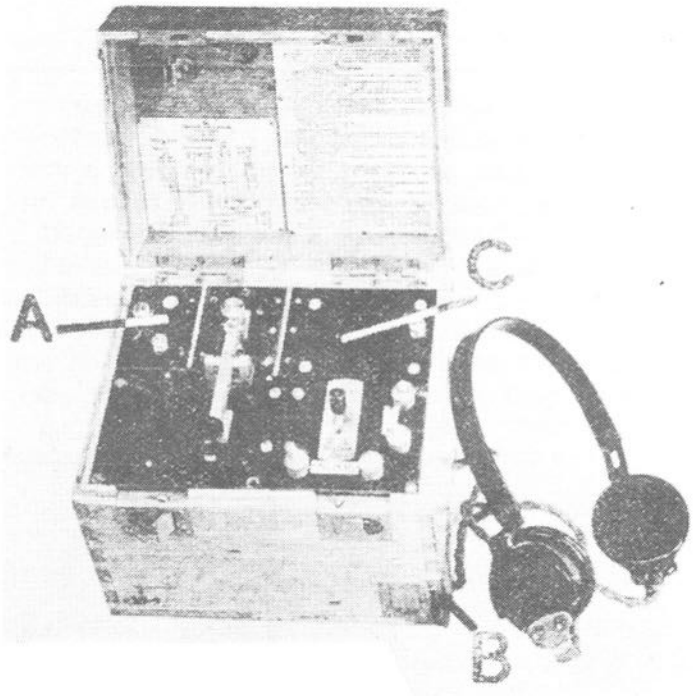

Fig. 4. "Apparado da campo per telegrafia ininter-cettabile - Mod. 1931". (Apparatus, field-telegraph, non-interceptable). The Italian Army copied the Fuller-phone in the early thirties. The circuit is similar to the British design, but no line balancing potentiometer is included.

via leaky or very long cables is possible, the normal range for reliable communication being 25-40 miles. Much greater ranges are possible under special conditions (eg, air lines in the desert) or by putting in a minor circuit change. As the Fullerphone works on d.c. only it can be used on one line simultaneously with a telephone set without any mutual interference.

Difficulties

Fullerphone circuits are, however, liable to some forms of interference. Difficulties in working are almost invariably due to interference from small currents picked up by the line, either by the earth, by earth faults, or by leakage from other currents. The interference caused by a steady earth current, or by leakage currents from other circuits, can be effectively balanced out at the receiving end by producing a current of equal strength but of an opposite direction to the interfering current. A potentiometer R, dry cell B2, and reversing switch S2 are provided for this purpose. Each station must adjust its own potentiometer as the currents which are picked up as earth faults will not necessarily be the same at each end of the line.

Fig. 5. Tobruk 1942... Mk IV Fullerphones in use at Australian Signal Headquarters in the desert.

Used in two wars

Initial issues of Fullerphones were made up from converted DIII field telephone sets. This type, however, was not the most successful. Toward the end of 1916, the Fullerphone was firmly established, and by 1918 most Divisions had adopted Fullerphones for all their forward circuits. After the armistice, improvements and modifications to the instrument were carried out. The basic principle, however, was never changed. During 1939 a

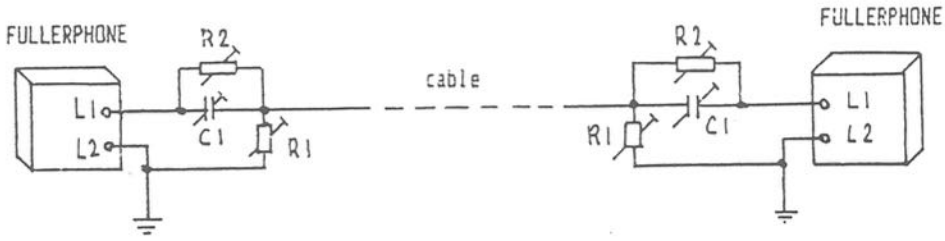

Fig. 6. Arrangement for cables up to 500-600 miles. Alterations to the standard Mk IV Fullerphone for this application included an increase of voltage on the line from 1.5 to 12 volts.

re-designed model, Mk IV, went into service. This was more sensitive than its predecessors, with a more easily adjustable buzzer/interrupter, and was simpler to use as it carried no telephone set.

The Fullerphone was designed as a non-interceptable signal instrument for static trench-warfare. But it was widely used during WW2 because of its other features, viz, the ability to work simultaneously with a telephone on the same line, and the capability of working through very long or leaky lines where telephone traffic was impossible.

In the South West Pacific, for example, the Australians made extensive use of the Fullerphone, and it more than lived up to its reputation when used in New Guinea resulting in a considerable saving of cables at a time when men and supplies were scarce resources.

During WW2 cases arose where a submarine cable circuit was available but the necessary terminal telegraph equipment was found to be totally destroyed or not immediately available. To ascertain to what extent Fullerphones could be used on submarine circuits of various lengths, trials were carried out, at the request of the War Department, by Cable & Wireless Ltd. The results exceeded all expectations, and ranges of up to 700 miles were obtained with faint but readable Morse signals at a maximum of 20 words per minute.

Finally

The attitude of signallers to their Fullerphones cannot be better described than in a poem written by Signalman R. Mellor and published in "Jimmy", the magazine of the Royal Signals in the Middle East.

ODE TO A FULLERPHONE

What is my greatest joy in life,
More precious even than my wife,
So comforting 'midst all this strife?
My Fullerphone.

How well I love your merry tricks;
Even when your buzzer sticks;
Delighting me with faint key clicks;
Oh Fullerphone.

How tunefully your buzzer throbs
As tenderly I turn those knobs.
Most fascinating of all jobs.
Oh Fullerphone.

Potentiometer, its true
I'm not sure what to do with you.
Yet even you add beauty to
My Fullerphone.

Oh how I pity those poor souls
Who daily work remote controls,
Attached to crazy wireless poles.
Oh Fullerphone.

They never hear the tuneful tones
Of perfect Morse within their 'phones:
Just atmospherics, shrieks and groans.
Oh Fullerphone.

But I must cease to write more verse.
Communication's getting worse.
No wonder that I rave and curse
At Fullerphone.

Asthmatic buzzers, - crazy keys.
How can one live a life of ease,
With damfool instruments like these
Foul Fullerphones!

Sigmn. R. MELLOR

Acknowledgements

The author is indebted to Major A.G. Harfield, B.E.M., Deputy Director of the Royal Signals Museum, for his help and permission to publish the photographs and diagrams in this article.

The Royal Signals Museum at Blandford Camp, near Blandford Forum, Dorset, is open to the public during weekdays from 8.30 to 1600, and a collection of Fullerphones is among many other signal instruments.