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THE BALSILLIE SYSTEM OF WIRELESS TELEGRAPHY AS EMPLOYED IN THE radiotelegraph STATIONS OF THE COMMONWEALTH OF AUSTRALIA.*

BY J. G. BALSILLIE.

The system of radiotelegraphy employed at the various stations in the Commonwealth is a unidirectional impulse excitation system in which the radiator is excited into oscillation by the use of three circuits permanently associated thereto, which three circuits and the radiator circuits for the purpose of definition are

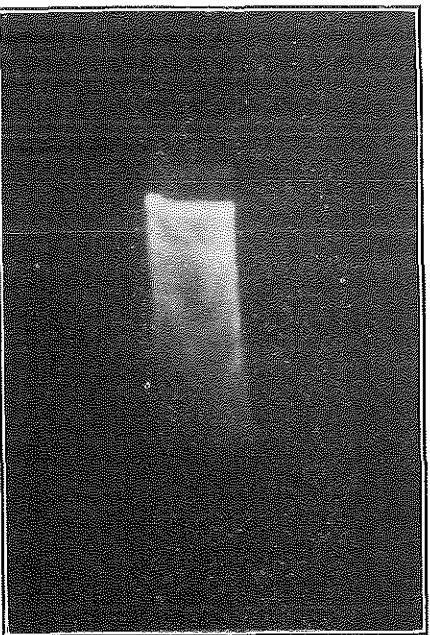


FIG. 1.—IMAGE OF DISCHARGE IN ROTATING MIRROR.

F Speed of mirror, 5,400 revs. per minute. Spark frequency, 360 per sec. Wave length, 600 metres. The multiple image is due to the thickness of the glass.

terned the primary, the charging, the exciting and radiator circuits. The primary circuit is connected to the charging circuit by means of a transformer, and arrangements are made that the electrical period of oscillation of the charging circuit is in resonance with the forced period of oscillation of the primary circuit. The exciting circuit which forms part of the charging circuit is connected to the radiator circuit by means of a condenser which is common to both circuits. The balance of circuits is arranged so that there is no reaction between these circuits. In operation the primary circuit charges the condensers, and the gap is so adjusted that the charge has reached its maximum before the condenser discharges across it. The discharge is not oscillatory, for reasons which are explained later, but a single discharge. This single discharge reverses the charge on the con-

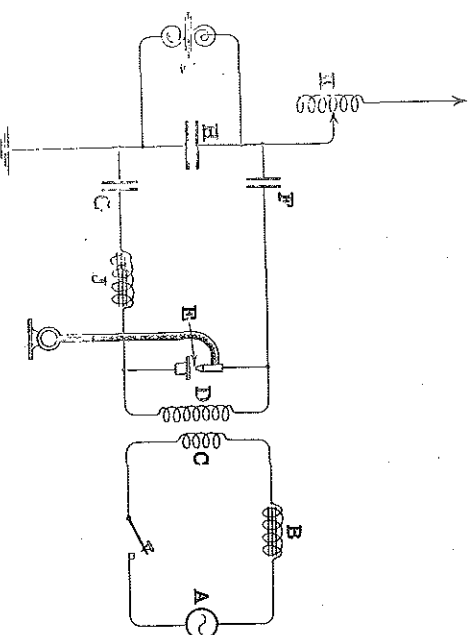


FIG. 2.—DIAGRAM OF CONNECTIONS OF THE BALSILLIE SYSTEM.

A =a rotary converter, B =a choking coil for adjusting load, C =the primary of a special transformer with high leakage factor, D =the secondary of this transformer, E =the spark gap, F , G , H =condensers, I =a spiral choking coil, J =inductance in the exciting circuit, K =inductance in the aerial circuit.

densers. It is evident that the reversed charge cannot be of the same value as the original charge, because a certain part of the energy of the original charge has been absorbed by the radiator, and on account of the charging circuit being in resonance with the primary circuit the reversed charge in the condensers finds a path of

less resistance through the secondary of the transformer than across the gap as the potential of the reversed charge is not sufficient to break down the gap. (By this it is intended that ionisation of the gap is not permitted to take place to any appreciable extent. The result is, therefore, that the energy not absorbed from the exciting circuit by the radiator circuit and reversed in polarity in the single discharge of the exciting circuit finds its way to the primary circuit via the transformer connecting the primary and charging circuits, wherein it is again utilised.)

Briefly, the system is a means whereby a radiator is excited by single impulse produced by the discharge of the condenser each for frequency period, arrangements being provided whereby the portion of the energy not imparted to the radiator is returned to the source of power, means being provided whereby the return of energy from the radiator to the condenser is prohibited.

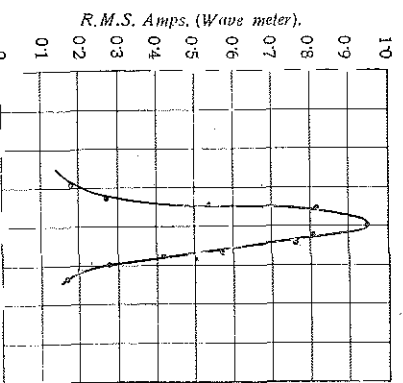


FIG. 3.—RESONANCE CURVE, NORMAL RADIATING CIRCUIT.

In this system the tuning of the exciting circuit to the radiator circuit is resorted to for the purpose of insuring that the condenser discharge circuit shall deliver a portion of its original store of energy to the radiator at such a rate that the radiator may most efficiently absorb it and after this has occurred there shall be no further action or reaction between the radiator and the condenser discharge circuit.

In respect of the single discharge in the exciting circuit the reader is referred to the photograph here reproduced (Fig. 1), which is taken by means of a rotary mirror, and which shows a single discharge taking place during each period of the low-frequency circuit.

The system will be understood by the following description. Referring to Fig. 2, the frequency of the current taken from the

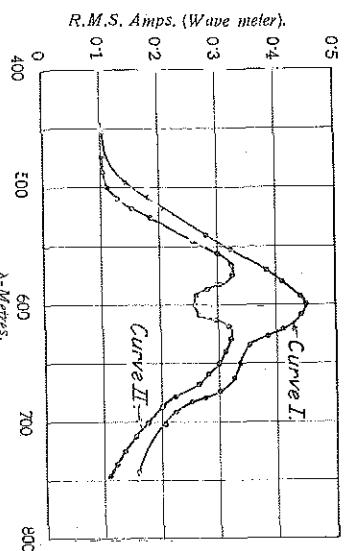


FIG. 4.

Curve I. Exciting circuit with spark-coil excitation.

II. Radiation circuit with exciting circuit energised as in Curve I.

notary converter A is approximately 350 periods per second, B is an ordinary choke coil with a movable core. The transformer C , D is an open magnetic circuit transformer with leakage factor of a definite value for a reason which will be explained later. The gap E is air-cooled with the object of preventing the formation of an arc. Air at the pressure of approximately 100 lb. per square inch is blown through one electrode, and impinges on the other electrode the diameter of the orifice being about $\frac{3}{4}$ in. The condensers F and G consist each of five jars, each having a capacity within 1 per cent. of 0.002 mfd. The condenser H consists of 14 such jars. I is the choking coil of such value that it does not offer any appreciable impedance to the flow of the 350 period current, but offers prohibitive impedance to the flow of an oscillatory current as compared with the path through H . J is a small tuning inductance; K is also a tuning

* Paper read before Section G of the British Association at Sydney.

inductance. Tuning is effected as follows: The radiator circuit is tuned by means of the inductance K to the wave-length it is desired to emit, the value of the coupling condenser H having been first determined. The circuit E, F, H, G, J is approximately tuned to the radiator circuit frequency. The circuit D, F, I, G, J is tuned as nearly as possible to resonance with the frequency of the current supplied from A. Thus it is seen that the inductance of the transformer secondary D, and, therefore its leakage factor, plays an important part in the adjustment of the system. In action the aerial is earthed through the spiral choke I until discharge takes place, owing to the fact that the charging current at a frequency of 350 periods does not charge the condenser H, which may be considered as short-circuited to this current by the inductance I. Therefore, the aerial may be considered as entirely earthed with regard to the charging circuit until the instant of the maximum charge of the condensers F and G. A discharge takes place across the gap E, the

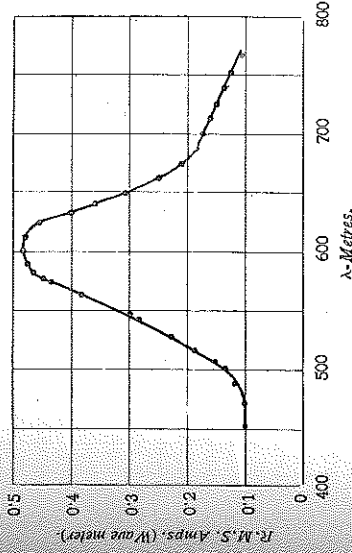


Fig. 5.—RADIATOR CIRCUIT SIMPLIFIER ENERGISED BY SPARK-COIL.

length of which is about 1 cm. The rate at which the discharge across the gap occurs is determined by the time constant of the circuits E, F, H, G, J, the value of the inductance J being adjusted to make this below that of the radiator circuit. The effect of the initial rush of current across the gap E is that the condenser H becomes charged and the energy poured into it is set free in the radiator, which oscillates at its own natural frequency only, of which the accompanying resonance curve (Fig. 3) for this aerial oscillation is evidence. The remainder of the charge in the two condensers creates an oscillation in the low-frequency circuit D, F, I, G, J. Thus, this energy that is the remainder of the charge in the two condensers is utilised at the next charge of the condensers, and owing to the periodicity of this circuit agreeing with the periodicity of the supply of current and the easier path through the transformer D is provided than across the gap, and thus no return flow across the gap occurs.

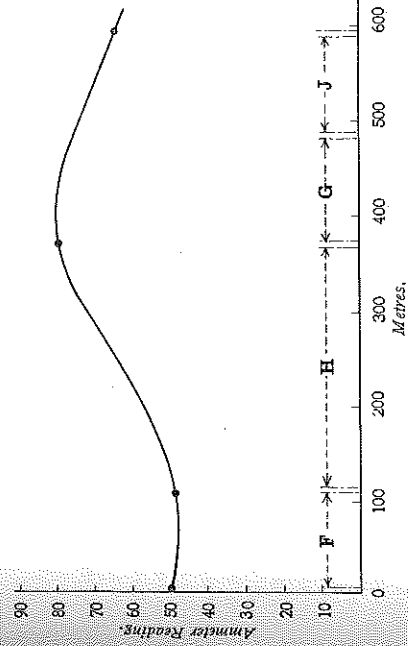


Fig. 6.

Endeavours have been made to produce an oscillatory discharge across the gap. This can only be done by introducing an extra inductance between D and E, so as to throw this circuit out of tune. The photograph (Fig. 1) is considered to be conclusive proof that the discharge under normal conditions is unidirectional, because it is absolutely a single impulse per period of current flowing in the primary circuit.

Fig. 4, curve I, shows the exciting circuit exactly as above, but with spark-coil excitation—that is to say, with resonance of the charging circuit destroyed and with purely oscillatory current flowing in this circuit.

Fig. 4, curve II, shows curves of the radiator circuit under these conditions, the double hump being very evident.

Fig. 5 is the curve of the radiator circuit simplifier energised by a spark-coil. Fig. 6 represents observations of current values at different points of the exciting circuit plotted out against the electrical dimensions in metres of that circuit.

The following particulars of the Melbourne radio-telegraph station are furnished:—

Mast 180 ft. high.
Squirrel-cage aerial, natural periodicity 550 metres.
Capacity, 0.0015 mfd.
High-frequency resistance on 600 metre wave, 12 ohms.
The following are the readings of the instruments:—
Direct-current generator, 80 volts.
Air-compressor takes 14 amperes at this voltage.
Rotary converter, 35 amperes no-load direct current.
Rotary converter, 65 amperes full load direct current.
Alternating current taken by sending instruments at 350 periods per second approximately.
Current in circuit, 58 amperes.
Potential on choke B, 49 volts.
Potential on transformer primary, 40 volts.
Potential on converter, 62 volts.
Wattmeter readings:—
Choke, 400 watts.
Transformer, 1,600 watts.
Converter, 2,100 watts.
Unaccounted for, 100 watts.
Current in air-wire, 16 amperes.

THE POWER PROBLEM IN THE ELECTROLYTIC DEPOSITION OF METALS.*

BY LAWRENCE ADDICKS.

Summary.—The author deals with the power requirements of present American practice in the electrolytic deposition of copper.

Copper, lead, nickel, silver, gold and some of the less common metals are now commercially refined by electrolysis. Lead, however, has such a large electrochemical equivalent that the power required is relatively small, and the tonnages of the precious metals refined are insufficient to demand special consideration. The electro-metallurgy of zinc is now being seriously studied, and the electrolytic refining of iron will follow upon any demand for pure iron as distinguished from the alloys commonly known as iron and steel. By far the larger proportion of the world's copper is electrolytically refined. These plants are being steadily extended as the annual production of copper increases, and present a power problem well worthy of special attention. A similar problem is beginning to arise in the leaching of ores followed by electrodeposition. Such work is now being inaugurated on a large scale in dealing with copper ores in Chile and around Butte, Montana. The energy used for deposition is much greater when insoluble anodes are used, as in the leaching propositions. With soluble anodes as used in copper refining, the voltage is almost entirely absorbed—to the extent of perhaps 95 per cent.—by the ohmic resistance in the circuit, and in general is about $\frac{1}{3}$ volt per cell. With peroxidised lead or similar insoluble anodes working in sulphate solutions it requires about 2 volts per tank to maintain the same current density, owing to the chemical energy required to decompose copper sulphate at the cathode with no equivalent energy of formation developed at the anode. Where the anode reaction can be utilised, at least in part, as by the introduction of sulphurous acid which is oxidised to sulphuric acid at the anode simultaneously with the deposition of copper at the cathode, an intermediate voltage will result. It is probable that large power installations for these leaching propositions will soon be required.

Narrowing this whole question down to a copper refining plant as typical of this general class of electrolytic processes, we have the following power limitations imposed by present practice: (a) Direct current; (b) say, 8,000 to 15,000 amperes; (c) say, 100 to 200 volts per circuit; (d) resulting in 800 to 3,000 kw. units—1,000 to 1,500 in present installations; (e) circuits electrically independent, to avoid cross leakage; (f) constant current; somewhat variable voltage—say, ± 20 per cent.; (g) steady current load night and day; (h) steam needed for heating electrolyte; (i) plants of from 3,000 kw. to 9,000 kw. should be considered.

The reasons for these limitations are as follows:—

(a) *Direct Current.*—This is obviously required by the nature of the process.

* Paper read before the American Electrochemical Society, slightly abbreviated.