lated neutron star is then roughly as follows. At birth the rapidly rotating neutron star has a low magnetic field of maybe 10^8 G, with the interior at a very high temperature. The heat flux from the centre drives the generation of the magnetic field over perhaps 10^4 years and reaches a saturation value of about 10^{12} G. During this time the object is spinning at the rotation rate it had at birth. Once the field has built up, the neutron star will start to spin down as it will be losing rotational energy through electromagnetic dipole radiation at the rotation frequency. Once the heat flow stops, field enhancement will cease and the magnetic field will decay slowly over the next few million years.

Since most pulsars are much older than the 10^4 years suggested as the generation time of their magnetic field, it is not easy to determine whether this mechanism is at play rather than the traditional mechanism in which the field is the 'fossil' field of the presupernova star. But some circumstantial evidence, at least, supports the former explanation.

In particular, observations of the supernova remnant MSH15-52 have recently revealed that it contains a young X-ray and radio pulsar which has a spin-down age of 1,550 years, much less than the estimated 10,000-year age of the remnant[3]. These apparent ages are clearly inconsistent if the magnetic field was present at birth; but if Blandford *et al.* are right, the neutron star was formed 10,000 years ago and only became a pulsar 1,000 years ago when the magnetic field built up. This delayed 'birth' of pulsar activity may also help to explain the very small number of pulsars observed within supernova remnants: the pulsars appear only after the remnant has lost its identity. However, beaming effects and poor radio sensitivity can more or less explain this anyway — existing techniques only detect one pulsar in every 1,000 that must exist in the Galaxy.

Another interesting argument is based on the measured value of the spin-down braking index for the young pulsar PSR0531+21 in the Crab Nebula. This should take the theoretical value of 3.0, based upon simple electromagnetic theory and a constant magnetic dipole moment[4]. But the observed value of 2.5 is only consistent with this simple theory if the magnetic field is still growing, as expected from the proposal of Blandford *et al.*

Continuing this line of reasoning, one might think that the recently discovered millisecond pulsar PSR1937+21, which has a period of only 1.6 milliseconds and apparently a very weak magnetic field[5,6] of $\sim 10^8$ G, might be in an early stage with its magnetic field still developing. The absence of any remnant of the supernova explosion suggests, however, that this is not the case and that other explanations[7-10] are required.

The recently observed dependence of the space velocities of pulsars on their magnetic fields[11] may also have a bearing on the proposal of Blandford *et al.* It is not yet clear how pulsars acquire their high space velocities of a few hundred kilometres per second or how the magnetic field is involved. If the velocity is due to asymmetry in a supernova explosion, then the magnetic field seems to be involved in providing the small amount of asymmetry required and cannot have changed substantially since birth — in which case the mechanism suggested by Blandford *et al.* cannot be at play. Alternatively, the pulsar may be accelerated during its early life by the asymmetric emission of electromagnetic radiation due to an asymmetric magnetic field configuration[12]. The absence of any observed relationship between the direction of proper motion and the direction of the rotation axis deduced from linear polarization measurements[11,13] argues against this process but, if it is nontheless correct, then the acceleration will occur only after the magnetic field has developed by the field enhancement mechanism of Blandford *et al.*

Blandford *et al.* themselves admit that their theoretical arguments are subject to a number of uncertainties; the observational evidence is also equivocal. It will probably take the discovery and study of more very young pulsars, like the Crab pulsar and MSH15-52, before it is clear whether they are correct or whether it is still more probable that the magnetic fields of neutron stars are a relic of the fields of their progenitors. □

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NATURE

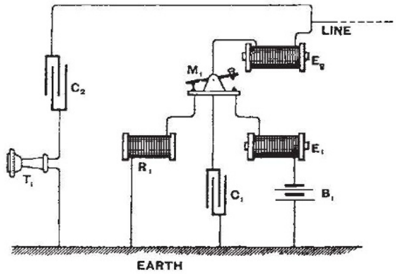
100 years ago

Telephony and telegraphy on the same wires simultaneously.

FOR the last eighteen months a system has been in active operation in Belgium whereby the ordinary telegraph wires are used to convey telephonic communications at the same time that they are being employed in their ordinary work of transmitting telegraphic messages. This system is the invention of M. Van Rysselberghe, whose previous devices for diminishing the evil effects of induction in the telephone service will be remembered.

The method previously adopted by Van Rysselberghe, to prevent induction from taking place between the telegraph wires and those running parallel to them used for telephone work, was briefly as follows:— The system of sending the dots and dashes of code — usually done by depressing and raising a key which suddenly turns on the current and then suddenly turns it off — was modified so that the current should rise gradually and fall gradually in its strength by the introduction of suitable resistances. These were introduced into the circuit at a moment of closing or opening by a simple automatic arrangement worked exactly as before by a key. And as induction from one wire to another depends not on the strength of the current, but on the rate at which the strength changes, this very simple modification had the effect of suppressing induction. Later Van Rysselberghe changes these arrangements for the still simpler device of introducing permanently into the circuit either condensers or elese electromagnets having a high coefficient of self induction.

Van Rysselberghe saw that if the telegraphic currents were thus modified and graduated so that they produced no induction in a neighbouring telephone line, they would produce no sound in the telephone if that instrument were itself joined up in the telegraph line. Why this is so will be more readily comprehended if it be remembered that a telephone is sensitive to the changes in the strength of the current if those changes occur with a frequency of some hundreds or in some cases thousands of times *per second.* On the other hand, currents vibrating with such rapidity as this are utterly incompetent to affect the moving parts of telegraphic instruments, which cannot at the most be worked so as to give more than 200 to 800 separate signals *per minute.*



The arrangement is shown where a "graduated" telegraph-set is intercalated into a telephonic system so that both work simultaneously, but independently, through a single line. The combined system at each end of the line will then consist of the telephone-set T_1, the telegraph instruments (comprising battery B_1, key M_1, and Morse receiver R_1), the "graduating" electromagnets E_1 and E_2, the "graduating" condenser C_1, and the "separating" condenser C_2. A single wire between Brussels, Ghent, and Ostend is now regularly employed for transmission by telegraph of the ordinary messages and of the telemeteorographic signals between the two observatories at those places, and by telephone of verbal simultaneous correspondence for one of the Ghent newspapers. From *Nature* **29**, 554, 10 April 1884.