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A DEVICE FOR MEASURING THE TENSION OF WIRES

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This apparatus was built a few years ago in order to provide an independent measurement of the tension of the wires stretched on the wire chamber frames. It makes use of a permanent magnet and of an amplifier to excite and maintain the self-oscillation of the wires. It is similar to any electromechanical oscillator but, whereas in general three different elements are used respectively for establishing the resonant frequency, for feeding-in the driving current and for picking-up the feedback signal, in this case the same functions are all performed by the wire.

As shown in the sketch of the circuit, the wire is a part of a Wheatstone bridge and any small noise, electrical or other, that displaces it gives rise to a signal which goes around the amplification loop in positive feedback. Thus the oscillation is built up and maintained either at the fundamental resonant frequency or at a harmonic, depending on the region of the wire covered by the magnetic field. The latter need not be uniform nor high. The oscillation is measured only by electrical means and the wire may be completely enclosed, except for the ends, in any sort of chamber, provided this is not made of magnetic materials.

A few words may be spent on the inner bridge shown on the circuit. One of the sides uses a string of three low-power filament lamps to make a r.m.s. power dependent resistor, in the same way as used in old RC oscillators (see, for instance, Elmore and Sands). The bridge's unbalance signal is mixed in negative feedback with the one coming from the wire's bridge and serves to stabilize the amplitude of oscillation at a very low level. The output signal goes to a loudspeaker and to a frequency meter and printer.

The measurement can be done "en passant", with contacts sliding on the printed circuit lines at the end of the wires. However, as simple as it is to automatize the prototype in full, this has not been done up to now because the device was sufficient for the intended purpose and priority has been given to the construction of apparatus for experimental physics. And certainly a less anachronistic circuit would give a vast improvement in the signal-to-noise ratio and allow the use of a weaker magnet!

Given the square root relationship between the natural frequency of the transverse oscillations and the tension of the wire, a change in frequency of 1% corresponds to a change in tension of about 2%. In our case, when the wire stretching machines are in proper operating conditions, the tension in any batch of wires varies by as much as $\pm$ 2 ÷ 3% r.m.s. value, with exceptional peaks of 5%. (1)

On long wires, higher harmonics, up to the seventh order, have been used in order to save on the magnetic field. No attempt has been made up to now to measure the velocity of propagation of transverse waves by exciting the wires in a pulsed mode, a system presumably less accurate and useful only in the case of very long wires.

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(1) An entirely new electronics for the wire stretching machines has been recently designed and built by N. Rasmussen and is due for publication in the near future. It allows a much smoother and faster operation and we expect the measurements to show a better uniformity in the wire tension, a welcome improvement also if the spread given above is acceptable in most cases.

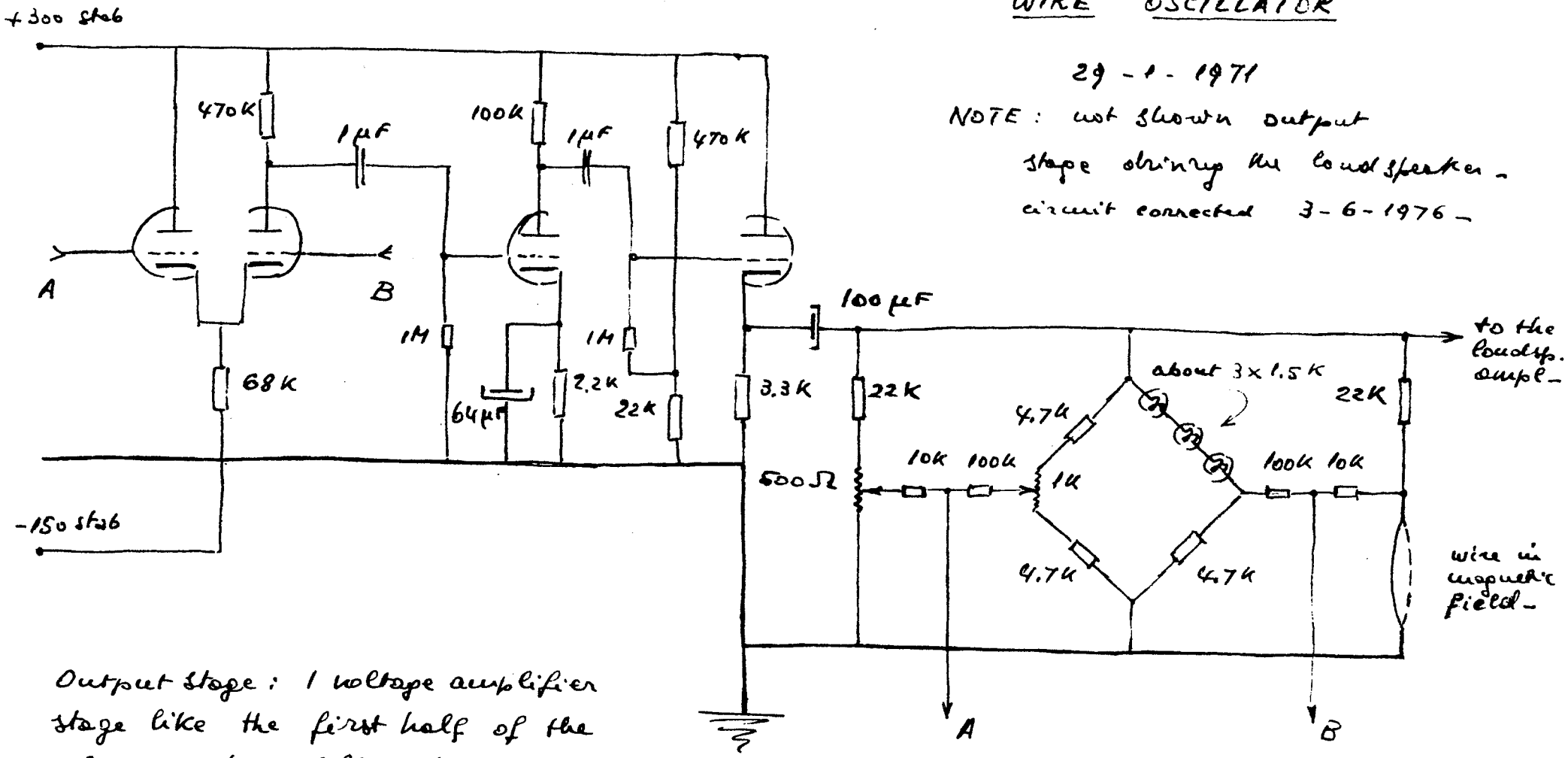
E803 CC

E802 CC
(E801 CC)

WIRE OSCILLATOR

29 - 1 - 1971

NOTE : not shown output stage driving the loudspeaker - circuit corrected 3 - 6 - 1976 -



Output stage : 1 voltage amplifier stage like the first half of the E802 CC above followed by a cathode follower stage having the loudspeaker in series with 1.5 KΩ paralleled by a 64 µF capacitor -