Q. Jl R. astr. Soc. (1986) **27**, 695–696

On the Origins of 'Quality Factor' *Q*

K.L.Smith
The Electronics Laboratories, The University, Canterbury, Kent CT2 7NT

(Received 1986 April 4)

The origins of the concept known as '*Q*' and its proliferation into seemingly disparate fields, as reported by Jeffreys (**1**, **2**) and McMullan (**3**, **4**), is indeed of considerable interest to historians of technology and those interested in scientific etymology.

My investigations appear to show that the concept of 'inductive purity' (ratio of inductive reactance at any frequency, to the unavoidable polluting resistance) was originally symbolized by *K* in work carried out by K.S. Johnson for the American Western Electric Company's Engineering Department (*c*. 1914) (**5**).

By 1920, Johnson (**6**) had changed the symbol to *Q*. He overtly stated that *Q* did not stand for 'quality factor', but that he had chosen it simply because *K* and other alphabetical symbols were already overworked.

By 1924 Johnson had established the use of *Q* in the public domain as a result of the appearance of his book (**7**). A little after this time it appears that V.E.Legg popularised 'quality factor' as a name for *Q* that has survived.

The breakthrough concerning the depth of meaning for *Q* came soon after telecommunications engineers realised the concept was applicable to LCR circuits at the frequency of resonance, ω_0. The immediate result was the well known relationship to the 'sharpness of resonance' and to the logarithmic decrement, δ (**1**).

Further, as the voltage across either reactance in the series LCR circuit was found to be QV_s, where V_s is the supply voltage driving current through the circuit, *Q* also became directly related to circuit magnification. This certainly links with concepts formulated by Tesla (**4**). The QV_s relationship also enabled H.A.Snow to develop the *Q*-Meter, which appeared on the market *c*. 1934.

The final generalisation of *Q* to quantify the ratio of stored energy to dissipated energy in one period of a cyclic process is the prime explanation of its appearance in characterisations of the rotating earth; bouncing balls; church bell performance, and in its sharpness of response form, spectral line analysis. I have discussed these relationships in more detail elsewhere (**8**).

A major problem remaining in the application of *Q*, is that its value becomes obscure when complex response curves are investigated. Typically, those associated with bandpass filters in electromagnetism and self-reversal phenomena in diffuse spectral lines are difficult to characterise with this single number, *Q*. Is it the *Q* of the emission feature or that of the (usually sharper) absorption feature that is most relevant? In the case of filters, communications engineers use a 'shape factor' parameter to describe the steepness of the filter skirts, *Q* having become meaningless across the multi-resonances and wide frequency band of the shaped bandpass response.

REFERENCES

(1) Jeffreys, B., 1985. *Q. Jl R. astr. Soc.*, **26**, 51.
(2) Jeffreys, B., 1985 (lett.). *Elect. & Wireless World*, **92**, 17.
(3) McMullan, D., 1985. *Q. Jl R. astr. Soc.*, **26**, 529.
(4) McMullan, D., 1985. (lett.) *Elect. & Wireless World*, **92**, 62.
(5) Johnson, K.S., 1914. Unpublished notes.
(6) Johnson, K.S., 1920. Unpublished notes.
(7) Johnson, K.S., 1924–25. *Transmission Circuits for Telephone Communication*, D.Van Nostrand.
(8) Smith, K.L., '*Q*', *Elect. & Wireless World*, **92**, 51–53.

GENERAL REFERENCE

Green, E.I., 1955. '*The Story of Q*', *Amer. Sci.*, **43**, 584–594.