

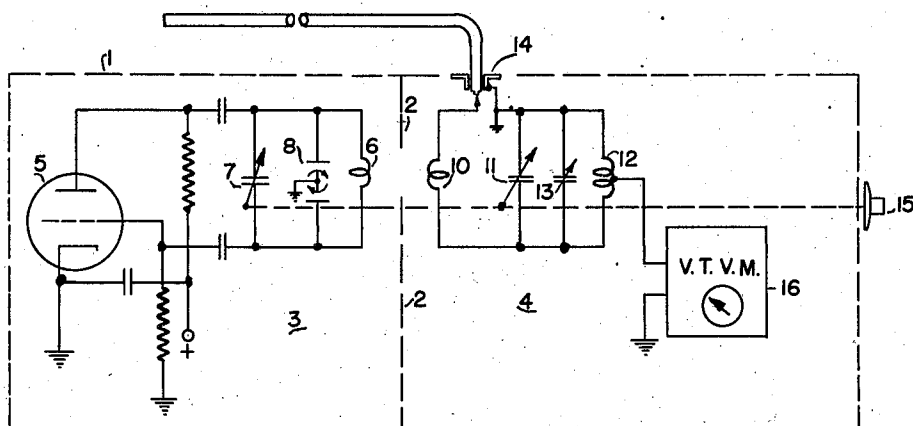
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METHOD AND APPARATUS FOR DETERMINING THE RESONANT FREQUENCY OF NETWORKS

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METHOD AND APPARATUS FOR DETERMINING THE RESONANT FREQUENCIES OF NETWORKS

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5 Claims. (Cl. 175-183)

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1 This invention relates to the determination of resonant frequencies of reactive networks and is particularly directed to the problem of ascertaining the resonant frequency of transmission line sections.

It is accordingly the object of the invention to provide a novel method and means of ascertaining the resonant frequencies of reactive networks.

A further object of the invention is to determine the velocity of propagation of a wave along a line section. This is accomplished by ascertaining the resonating frequency for an untermi-
nated line section of known length. At such frequency the line section comprises an odd
quarter wave multiple of the wave length propa-
gated therein. Inasmuch as the order of mag-
nitude of the velocity is ordinarily known from
the construction of the cable, the particular mul-
tiple may be obtained. Consequently, from the
value of the exciting frequency, the velocity of
propagation may be calculated.

An exemplary form of apparatus suitable for effectuating the method of the present inven-
tion is shown in the drawing, in connection with
which the invention will be further described.

The system of the present invention includes a
shielding cabinet 1 subdivided at 2 into two com-
partments 3 and 4. Compartment 3 contains
a variable frequency oscillator including a triode
5 coupled conventionally with a tuned circuit in-
cluding inductance 6 and tuning capacitor 7. Balanced capacitor 8 is provided for trimming
adjustment of the oscillator frequency.

The oscillator inductance is very loosely
coupled through shield 2 with inductance 10,
which forms a tuned circuit with tuning capacitor
11 and inductance 12. Trimming capacitor 13 is
also provided.

The desired coupling of inductances 6 and 10
may be established by employing a sheet metal
shielding member 2 suitably apertured. Under
such loose coupling the coil 10 may be considered
as driven by a constant series voltage.

The coupled circuit includes in series a jack
14 for receiving connection of the network whose
resonant frequency is to be determined. In the
drawing an untermi-
nated concentric line section
is shown, which is resonant at frequencies at
which it constitutes a quarter wave length or an

2 odd multiple thereof. At resonant frequencies
the impedance appearing across jack 14 will con-
stitute a pure resistance, which will not affect
the resonant frequency of the tuned circuit.

5 As shown in the drawing, the tank condenser
7 and the condenser 11 of the tuned circuit are
ganged to a common control 15. For lining up
the circuits, a solid conductor may be inserted
to short jack 14 and trimmers 8 and 13 adjusted
so that the natural resonant frequencies of the
oscillator tank circuit and the coupled circuit
substantially coincide throughout the tuning
range. This may be determined by a vacuum
tube voltmeter 16 of any suitable type connected,
for instance, to coil 12. On correct tracking the
oscillator and coupled circuit are tuned together
through the range, and voltmeter 16 will indi-
cate a substantially uniform voltage throughout.

On connection of the network to jack 14, the
20 reactance thereof will detune the coupled circuit
so that no voltmeter indication is obtained except
at the resonant frequency of the network. Con-
sequently the latter may be determined immedi-
ately by adjusting the control 15 for a maximum
deflection of voltmeter 16.

For obtaining the velocity of propagation with-
in a cable section, the apparatus may be employed
to yield direct results by suitable calibration
of control 15. Assuming normal construction
of control 15. Assuming normal construction
30 wherein the average dielectric constant within
cables of the type considered is 2.25, and that
measurements are to be taken at about 100 mc./s.,
the wave length within the cable will be sub-
stantially 200 cm., and a three quarter wave
section is 150 cm. long. If, therefore, a 150 cm.
section cable be inserted in the jack 14, its res-
onant frequency adjacent 100 mc./s. as deter-
mined by control 15 corresponds to three quarter
wave lengths. Since the period required for
propagation to the end of the line is $\frac{3}{4} \cdot \frac{1}{f}$ sec-
40 onds, the velocity in centimeters per second is
200 f . The velocity expressed in per cent of the
velocity in free space is $\frac{2}{3} f$ where f is expressed
in megacycles. Control 15 may be directly cali-
brated in the velocity of propagation, if desired.

Where a number of cable sections are being
tested, the reading of vacuum tube voltmeter 16
varies inversely with their attenuation and will
afford a rough indication of the relative proper-
ties of the lines in this respect.

Where the constructional characteristics of a line are unknown and cannot conveniently be determined, the quarter wave length multiple may be found by ascertaining two adjacent resonant frequencies of the section. Since the wave length is inversely proportional to the frequencies, and only the ratio of the former is required, the desired information may be derived from the formula

$$(2n+1)\lambda/4 = (2n+3)\lambda'/4$$

where λ' is the shorter of the adjacent resonant wave lengths.

It will be understood that the other line lengths may be employed and that the illustrations discussed are exemplary only. It is further apparent that a short-circuited half wave or multiple half wave section may be employed.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. Means for ascertaining the resonant frequency of an electrical network including an oscillator tunable over a range of frequencies, a circuit tunable over said range of frequencies coupled to said oscillator, common control means for simultaneously tuning the oscillator and the coupled circuit together through said range in tracking coincidence, means for indicating the response developed in the coupled circuit, and means for electrically coupling a reactive electrical network with said coupled circuit to detune the latter except at the resonant frequency of the network.

2. Means for ascertaining the resonant frequency of an electrical network including an oscillator tunable over a range of frequencies, a circuit tunable over said range of frequencies coupled to said oscillator, common control means for simultaneously tuning the oscillator and the coupled circuit together through said range in tracking coincidence, means for indicating the response developed in the coupled circuit, and means for connecting an electrical network in series in said coupled circuit whereby the latter is detuned and unresponsive except at the resonant frequency of the network.

3. Means for ascertaining the resonant frequency of a transmission line section including an oscillator tunable over a range of frequencies, a circuit tunable over said range of frequencies coupled to said oscillator, means for simultaneously tuning the oscillator and the coupled circuit together through said range in tracking coincidence, means for indicating the response developed in the coupled circuit, and a transmission line section connected in series in said coupled circuit whereby the latter is detuned and unresponsive except at the resonant frequency of the line section.

4. Means for ascertaining the resonant frequency of an electrical network including an oscillator circuit tunable over a range of frequencies, a circuit tunable over said range of frequencies coupled to said oscillator, means for simultaneously tuning the natural frequencies of the oscillator circuit and the coupled circuit over said range in tracking coincidence, means for electrically coupling a reactive electrical network with one of said circuits to detune said circuit except at the resonant frequency of the network, and means for indicating the signal level in the coupled circuit.

5. The method of ascertaining the resonant frequency of a reactive network electrically coupled to a resonant circuit excited by a tunable oscillator comprising the steps of tuning the oscillator over a range of frequencies, simultaneously tuning the resonant circuit over the same range of frequencies in tracking coincidence with the oscillator, and indicating the signal level in the resonant circuit to determine the frequency at which the resonant circuit is not detuned by the reactive network.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,091,109	Schiepe	Aug. 24, 1937
2,162,827	Schrader	June 20, 1939
2,174,963	Broaten	Oct. 3, 1939
2,320,175	Dennis et al.	May 25, 1943
2,324,525	Mittelman	July 20, 1943