CONSTANT INTENSITY SOURCES OF MONOCHROMATIC LIGHT

FIG. 1

FIG. 2
FIG. 3
The present invention relates to monochromatic sources of light of the type described in a copending patent application, Serial No. 197,983, filed May 28, 1962, now abandoned, for "Improvements in Monochromatic Light Sources" and assigned to the same assignee.

This copending application describes a source of light operated by excitation of an ionized gas or plasma by means of a high-frequency field. Such sources include a tube with an ionizable gas, whose ends are surrounded by coils which are brought to alternating potentials in phase opposition. The central region of the tube is clear of any coil and is thus subjected to an alternating electric field of high value.

It is an object of the present invention to provide an improved source of the above type, whose impedance is constant and does not depend on the evolution of the plasma, contained in the tube.

According to the invention, the two coils respectively surrounding the ends of the tube are connected in series with a capacitor, the whole having such a capacity that the circuit, thus built up, is resonant and substantially equivalent to a resistance.

According to another feature of the invention, means are provided for keeping the frequency of the oscillator, which provides the energy necessary for operating the sources of light, equal to the resonance frequency of the circuit formed by the above coils and capacitor during the operation of the tube.

The invention will be better understood from the following description with reference to the appended drawing wherein:

FIG. 1 shows schematically one embodiment of the device described in the above mentioned copending application.

FIG. 2 shows an embodiment of the invention, and FIG. 3 shows another embodiment of the invention.

The same reference numbers designate the same elements throughout the drawing.

FIG. 1 shows a glass tube 1, filled, for example, with a mixture of alkali vapour and argon. The tube is surrounded at its two ends by identical windings 2 and 3 which are connected through a solenoid 9, the midpoint of which is grounded. Circuit 2, 9, 3 is fed by a high-frequency generator 10. While this arrangement possesses certain definite advantages, it has, however, certain drawbacks.

When the plasma is being generated and during the evolution thereof, the capacity between planes A and B varies, due to the variation of the dielectric constant of the plasma. There results an impedance variation at the terminals of the voltage generator.

FIG. 2 shows how this drawback may be avoided according to the invention.

A coaxial cable 11, whose outer conductor is grounded, has its inner conductor connected to a high-frequency generator 10, one of whose terminals is grounded. This conductor is connected to the first turn of winding 2. The outer conductor is connected to the extreme terminals of windings 2 and 3 respectively.

A capacitor 12 is placed according to the invention in series with windings 2 and 3. This capacitor is so adjusted that the circuit with the inductance of windings 2 and 3 is tuned to the frequency of oscillator 10. As a result, circuit 2-3-12 forms a resonant circuit which offers at the terminals of generator 10 a substantially pure resistive impedance. A cable 11, the characteristic impedance of which has this value may be used. A matching device known in the art may be provided.

An advantage of this arrangement is that source 10 may be situated as far away from tube 1 as may be desired, so avoiding the presence of any magnetic field in the tube, without the risk of standing waves arising in the cable.

However, this arrangement has a drawback. Region A, B of the tube, where there are no winding turns, behaves as a capacity in parallel with capacitor 12, and the value of this capacity varies with the evolution of the plasma. The resonant circuit becomes detuned in consequence.

The arrangement of FIG. 3 allows this drawback to be avoided. This arrangement includes a feedback loop such that the system always oscillates at the natural resonance frequency of the excitation circuit.

Windings 2 and 3 are mounted in the same manner as in FIG. 2. The first stage 20 of oscillator 10 is a triode connected in a conventional manner. The cathode is grounded by means of a resistance 21 and a capacitor 22 in parallel. The inner conductor of cable 11 is connected to the grid of tube 20. This grid is also connected to ground through a resistance 23 equal to the cable characteristic impedance. The anode is fed through an oscillator circuit 24 consisting of a capacitor 25 and an inductance coil 26 in parallel, coil 26 having its center point connected to the high-voltage source. The set of symmetrical tubes 30 and 31, whose cathodes are grounded and grids connected through decoupling capacitors to the respective terminals of coil 26, amplify the power delivered by the first stage. A coaxial cable 27, whose inner conductor is connected to the secondary winding of transformer 28 and to the first turn of winding 3 transmits the power from the amplifier to the excitation winding 2-3 with the impedances matched according to known art.

The invention consists in collecting at D a part of the voltage across the terminals of the oscillating circuit 2-12-3 and feeding it back as a feedback voltage to amplifier 30-31.

The Q-factors of the oscillator circuits being low, compared to those of the excitation oscillating circuit, and the lengths of the connecting cables 27 and 11 adjusted to meet phase requirements, the system 20-30-31 forms a positive feedback circuit whose oscillation frequency is obtained when the reaction voltage on the grid of tube 20 is a maximum, in other words when the oscillator frequency is equal to the resonance frequency of the oscillating circuit 2-3-12.

Under these conditions maximum efficiency is obtained during the evolution of the plasma, whatever its physical characteristics may be.

A source of light, according to the invention, offers numerous advantages over known equipment.

During the evolution of the plasma, i.e., either during its formation or during its working phase, the oscillator always remains matched to the characteristics due to this evolution.

This provides great flexibility and makes it possible to use a generator requiring only a minimum amount of power.

During the working phase of the plasma, the constancy of the useful power considerably contributes to improving the constancy of the radiation generated.

This point is very important in many applications (standard light sources, optical pumping) where it is de-
sirable to obtain a luminous source with as little variable an intensity as possible.

Lastly, the light source, produced in this way, can, as previously mentioned, be placed as far as may be desired from the oscillator which generates the excitation current.

This condition is very important for certain applications, for it avoids the harmful consequences of stray magnetic fields produced by currents flowing in the oscillator circuits.

This effect is very marked when the light source is used as a pumping or optical resonance source, as in the case of caesium clocks or optical resonance magnetometers.

It is strictly necessary to avoid all stray magnetic fields which would disturb measurement directly in the case of magnetometers or indirectly, through the frequency variation corresponding to a spurious Zeeman effect, in the case of optical pumping or of caesium clocks.

Of course, the invention is not limited to the embodiments shown and described, which were given solely by way of example.

What is claimed is:

1. A monochromatic source of light comprising: a tube enclosing an ionizable gas, said tube having two ends and a central portion; two coils respectively surrounding said ends and having respective low impedance tapped portions; a capacitor building up a circuit in series with said two coils; coaxial means for applying an alternating voltage to one of said portions; and means for tuning said circuit to the frequency of said voltage.

2. A monochromatic source of light comprising: a tube enclosing an ionizable gas, said tube having two ends and a central portion; two coils respectively surrounding said two ends and having respective low impedance tapped portions; central portion being clear of any coil; a capacitor connected in a series circuit with said two coils; an alternating current source including means for controlling its operating frequency coupled by coaxial line to one of said portions; said capacitor and said two coils building up a resonant circuit at a predetermined frequency; said frequency controlling means comprising an automatic frequency control, for making the frequency of said source equal to said predetermined frequency.

3. A monochromatic source of light comprising: a tube enclosing an ionizable gas, said tube having two ends and a central portion; two coils respectively surrounding said two ends and having respective low impedance tapped portions, said central portion being clear of any coil; a capacitor connected in a series circuit with said two coils; an alternating current source including means for controlling its operating frequency coupled by coaxial lines to said portions; said capacitor and said two coils building up a resonant circuit at a predetermined frequency; said alternating source comprising an oscillator and a feedback loop between one of said coils and said oscillator for keeping the operating frequency of said oscillator equal to the instantaneous frequency of said resonant circuit.

4. A monochromatic source of light comprising: a tube enclosing an ionizable gas, said tube having two ends and a central portion; two coils respectively surrounding said two ends and having respective low impedance tapped portions, said central portion being clear of any coil; a capacitor connected in a series circuit with said two coils; an alternating current source including means for controlling its operating frequency, coupled by coaxial lines to said portions; said capacitor and said two coils building up a resonant circuit at a predetermined frequency; said alternating current source comprising: an oscillator, having an input and an output; an amplifier connected to said output and having an output; a first coaxial cable connecting said input of said oscillator to said resonant circuit; and a second coaxial cable connecting said output of said amplifier to said resonant circuit for forming a positive feedback loop.

References Cited by the Examiner

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Number</th>
<th>Date</th>
<th>Inventor</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,947,003</td>
<td>2/1934</td>
<td>Finch et al.</td>
<td>331—168</td>
</tr>
<tr>
<td>2,272,851</td>
<td>2/1942</td>
<td>Ramsey</td>
<td>331—177</td>
</tr>
<tr>
<td>2,974,243</td>
<td>3/1961</td>
<td>Marrison</td>
<td>315—248</td>
</tr>
<tr>
<td>3,109,960</td>
<td>11/1963</td>
<td>Bell et al.</td>
<td>315—248</td>
</tr>
<tr>
<td>3,170,086</td>
<td>2/1965</td>
<td>Bell</td>
<td>315—248</td>
</tr>
</tbody>
</table>

GEORGE N. WESTBY, Primary Examiner.

F. A. ADAMS, S. A. SCHNEEBERGER, Assistant Examiners.