Moving Coil Recorder Design

D.C. Resistance of Moving Coil.

See Sketch No. 1.

Material 16.

Specific Resistance, Kay'sLarry page 25
18°C, 99% RH, 2.94 x 10⁻⁶ (3217) ohm cm.
Say 3 x 10⁻⁶ ohm cm.

Dimensions:

<table>
<thead>
<tr>
<th>Part</th>
<th>Length (cm)</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two curved portions</td>
<td>2 x 13</td>
<td>4 x 1</td>
</tr>
<tr>
<td>Three straight to tensions</td>
<td>3 x 5</td>
<td>4 x 1</td>
</tr>
<tr>
<td>Core tension (dual core)</td>
<td>6 x 2</td>
<td>4 x 1.2</td>
</tr>
<tr>
<td>120° 51°e plus side in parallel</td>
<td>5 x 1</td>
<td>4 x 1</td>
</tr>
</tbody>
</table>

Without glues

\[
\frac{L}{A} = \frac{2.5 + 1.5 + 1.2 + 0.5}{0.02 + 0.04 + 0.08 + 0.08}
\]

65 65
60 65
50 65
15 15
15 15

\[ k = \frac{123.75}{12} \]

Resistance = 123.75 x 3 x 10⁻⁶ Ohms
= 0.371 x 10⁻³ Ohms

Changing to cm²

\[
\frac{L}{A} = 65 + 7.5 + 15 + 6.25
\]

\[
\frac{L}{A} = 123.75 \text{ cm}^{-1}
\]
Inductance of R.C. Field System

Stainless laminations 10 x 0.10" thick
Take $\mu$ as 450.

Area \( 10 \times 10 \text{ mm}^2 = 10 \text{ cm}^2 \).

Length \( = 10 + 12 \times 2 + 11 \times 1 + 11 \times 2 \)
\[= \frac{10}{2} + 15.7 + 18 + 34.6 + 22 \]
\[= 124.3 \text{ mm} \]
\[= 12.43 \text{ cm} \]

\[L = \frac{4\pi RL}{C} \times 10^{-9} \]
\[= \frac{4\pi \times 1 \times 450}{1243} \times 10^{-9} \]
\[= 0.455 \times 10^{-9} \]
\[= 0.455 \mu\text{H per turn} \]

Tuning Frequency at which \( L \) equals \( R \) of coil
\[f = \frac{\omega}{2\pi} \text{ Hertz} \]
\[= \frac{377 \times 10^3}{455} = 815 \text{ Hz} \]
\[f = 130 \text{ Hz} \]

Taking coupling factor as 0.02.

Leakage inductance \[= 0.02 \times 0.455 \mu\text{H per turn} \]
\[= 9.1 \mu\text{H per turn} \]
Winding to Make Copper and NC Resistance = 1200Ω

AC resistance = 0.371 x 10⁻³

Winding Dimensions

Area = 2 x 3.4 x 4.6 m⁻²
= 77.4 m⁻² = 774 cm⁻²
= 12 in⁻².

Mean Turn = 4 x 154 = 616 cm = 6.16 cm.
= 242 cm².

Volume = 12 x 2.42 = 29.2 in³.

Surface AC resistance to be stepped to 80Ω.

Turns = \( \frac{800}{1087/10^{-3}} \) = 11.26 x 10³ turns
= 1470 + 164

Area available = 12 in²

Turns/in² = 464 = 3870
Use 32 Gauge.

R/in³ = 0.9Ω.

Resistance = 29 x 2.92 = 84.6Ω
Total Turns = 884.

Increase Turns by \( \sqrt{\frac{100}{884}} \) = 498 Turns,
Say 490 Turns.

490 turns of 29 gauge enamelled.

500 Turns of 29 gauge enamelled.
AC resistance x 500 = 92.7Ω.
Copper = 5.8Ω.

250 + 250 Turns of 29 Gauge.
Moment of Inertia of Moving Coil

Density of Al = 27 grs/cm³

<table>
<thead>
<tr>
<th>Sides of Coil</th>
<th>Mean Radius cm</th>
<th>Volume cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curved</td>
<td>(15)²/12</td>
<td>64</td>
</tr>
<tr>
<td>Flat Ends</td>
<td>(15)²/75</td>
<td>28.9</td>
</tr>
<tr>
<td>Stylus Bar</td>
<td>(15)²/33</td>
<td>18.75</td>
</tr>
<tr>
<td>Tranunion</td>
<td>(15)²/111</td>
<td>17.96</td>
</tr>
<tr>
<td>Shaft</td>
<td>(15)²/122</td>
<td>17.15</td>
</tr>
</tbody>
</table>

Volume x Radius² = 64 x 112 = 7170

18.75 x 12 = 225.0
54.33 x 32 = 1737
215 x 21 = 4520
4.5 x 45² = 2030
2 x 151 = 302

\[ \text{Total Volume} = 18009 \text{ cm}³ \]

\[ M_{oI} = 18 \times 27 \text{ g cm}³ \]
\[ = 0.486 \text{ g cm}². \]

About 0.35 g cm² for new arrangement with vertical stylus.
Angular Velocity corresponding to Normal Level.

Normal level = 5 divisions at 1000 v.

\[ \text{Velocity} = \frac{\sqrt{2} \times 2.54 \times 10^{-3}}{\sqrt{2}} = \frac{4.23}{1.8} \text{ cm/sec.} \]

With stylus radius 1.8 cm:

Angular Velocity = \frac{4.23}{1.8} = 2.35 \text{ rad/sec. R.M.S.}

With 18 mm stylus:

Angular Velocity corresponding normal level = 2.35 radians/sec. R.M.S.
Electromechanical Conversion Factors

Let \( H \) be field in gap.
Let \( r \) be radius of moving coil.
Let \( \omega \) = angular velocity rad/sec.
Let \( T \) = Torque dyne cm/sec.
Let \( l \) = length of gap.

All electrical properties refered to 500 turn secondary winding.

\[
V = \text{Volts} = 2Hr\pi l \times 10^{-8} \times 500
\]
\[
T = 2Hr\pi l \times 10^{-1} \times 500
\]

Put \( 500 \times 2Hr\pi l = k \)

\[
V = k \times 10^{-8}
\]
\[
I = \frac{kT}{k} \times 10^{1}
\]
\[
VI = k \times T \times 10^{-7}
\]

Impedence is \( \frac{V}{I} = \frac{k^2 \pi l}{T} \times 10^{-9} \)

\[
V = k \times 10^{-8}
\]
\[
I = \frac{V}{k} \times 10
\]
\[
Z = \frac{k^2 \pi l}{T} \times 10^{-9}
\]
\[
k = 2 \times 500 \times Hr\pi l
\]

In present case \( V = 0.3 \) \( E = 1.0 \) \( R = 800 \Omega \).

If \( H = 6000 \) \( R = 4.8 \times 10^6 \)
\( H = 10,000 \) \( R = 8 \times 10^6 \)

Mechanical Impedence is \( \frac{V}{\alpha} = \frac{kT \times k \times 10^{-7}}{V} = \frac{k^2 \times 10^{-6}}{2} \).
Equivalent circuit of Recorder.

For 10,000 Field

Mass of Armature:

\[ Z = R \frac{K}{T} \times 10^{-9} = \frac{h^2}{R^2} \times 10^{-9} = \frac{1}{L C} \]

\[ = 64 \times 10^3 \times \frac{1}{486} \times 0.0486 \]

\[ = 131.5 \times 10^3 \]

\[ \approx \frac{10^6}{\omega \times 7.6} \]

i.e. 7.6 MF.

Equivalent spring to tune at 1000:

\[ 10^6 \times 10^{-6} = \frac{10^6}{9.425^2} \]

\[ L = \frac{10^6}{9.425^2 \times 7.6 \times 10^6} = 1.46 \times 10^{-3} \text{ H} \]

Volts required at output = \( R \times 10^{-8} \)

\[ = 8 \times 10^{-6} \times 250 \times 10^{-6} \]

\[ = 1.87 \times 10^{-9} \]

Impedance looking back to be 2500 mechanical ohms at "s" point = 2500 \( \times 1.3^2 \) torque ohms = 8100 torque ohms.

Desired \( Z_2 = \frac{8 \times 10^{-6}}{8100} \times 10^{-6} \)

\[ = \frac{64 \times 10^6 \times 10^{-6}}{8100} \]

\[ = \frac{64000}{8100} = 7.9 \text{ ohms} \]

Leakage Inductance per turn = \( 9.1 \text{ mH/turn} \)

In 500 turns = \( 9.1 \times 10^{-4} \times 25 \times 10^6 \)

\[ = 2.27 \times 10^{-3} \text{ H} \]

Short Inductance = \( 0.455 \times 10^{-6} \times 25 \times 10^6 \)

\[ = 0.114 \text{ H} \]
Equivalent Mechanical Circuit (out)

Resistance of moving coil = 92.7 say 90
  " Fixed coils = 5.8 say 6.0

Recorder then becomes.

![Diagram of electrical circuit with annotations and calculations]