University of California
Berkeley

College of Engineering
Department of Electrical Engineering
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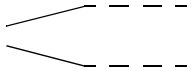
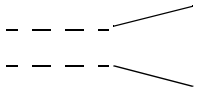
EE225D Spring,1999

Music Production Models

Lecture 14

Summary of Music Production

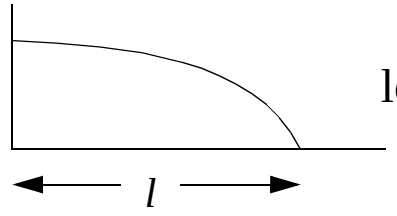
- Comparison of Trumpet, Violin, Piano
- Modes of a Trumpet
- Mousepiece and Bell for Trumpet
- Range of Tube, Trombone, French Horn, Trumpet
- Evolution of Trumpet design ⟶ Harmonic Structure
- Why does Mouthpiece  Lower High Frequencies?
- Why does Bell  Raise Low Frequencies?

Trumpet

- Blow into open tube.

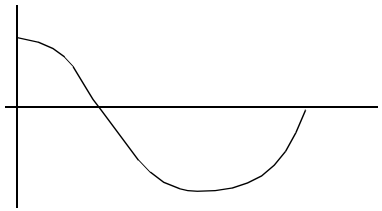
$$p = Z_o(u^+ + u^-)$$

pressure is zero at end.

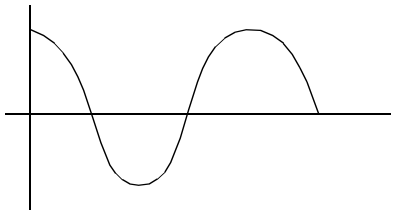


lowest mode

$$f = \frac{C}{\lambda} = \frac{C}{4l}$$



3f



5f

example $l = 127\text{cm}$

$$f_o \approx \frac{34000}{4 \times 127} \approx 68\text{Hz}$$

$3f_o$, $5f_o$, etc.

The lowest mode of this piece is comparable to the higher modes of the tube.

Therefore, the effective tube length increases for higher frequencies, but not for lower frequencies.

So lowest first mode is ~ 60Hz.

Bell higher frequencies have λ smaller than bell opening. So they don't produce standing waves. But lower frequencies do.

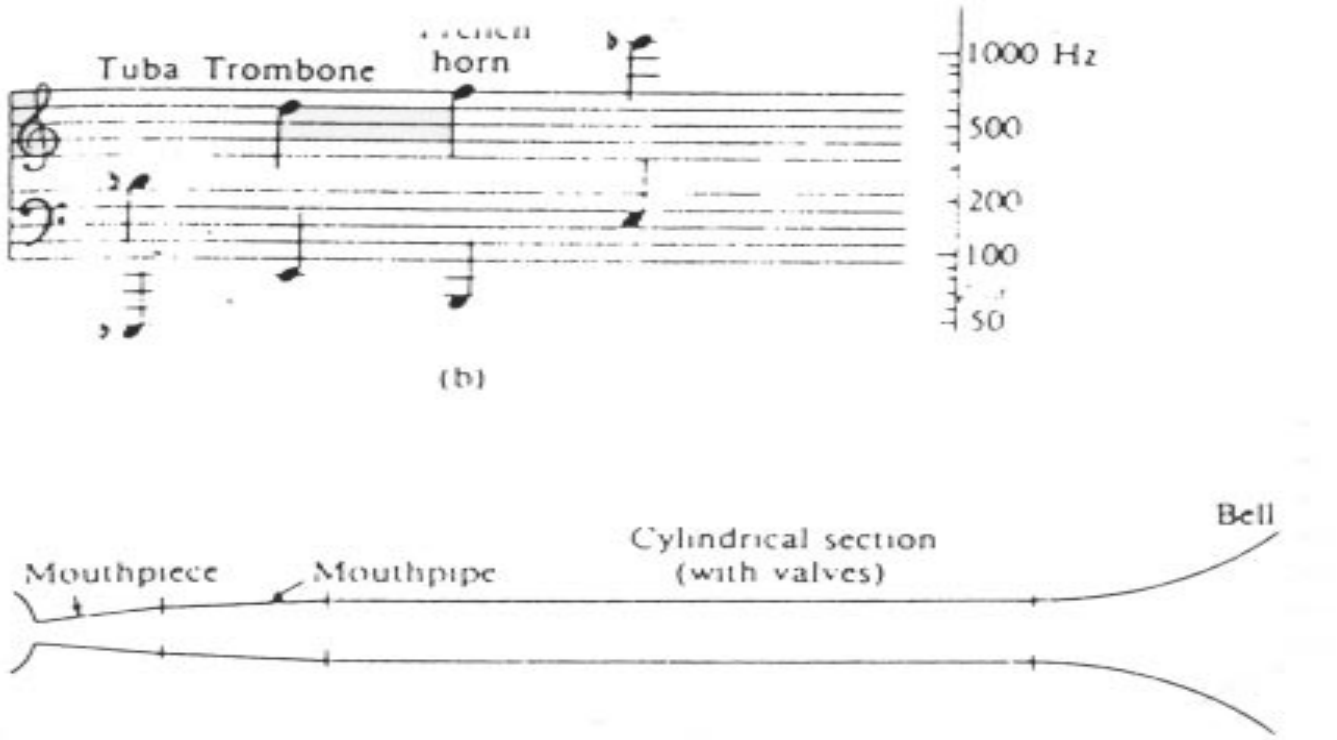


Figure 12.21 : Cross section of a brass instrument

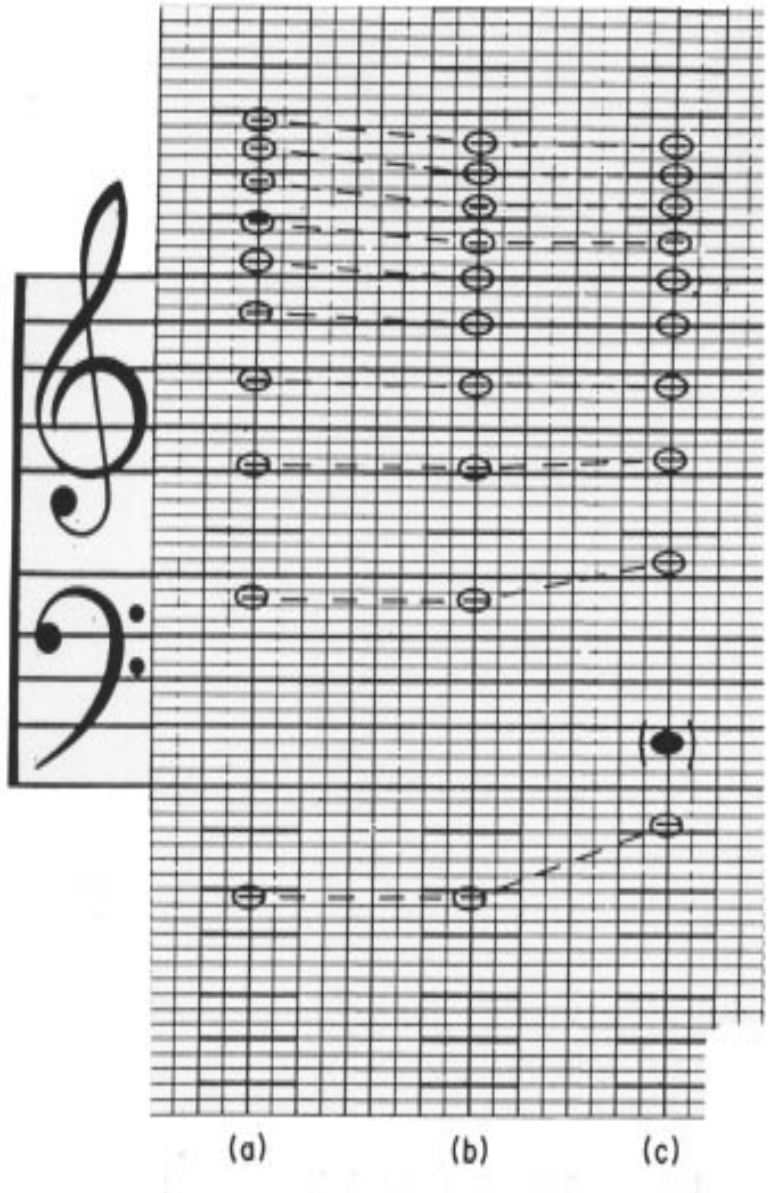
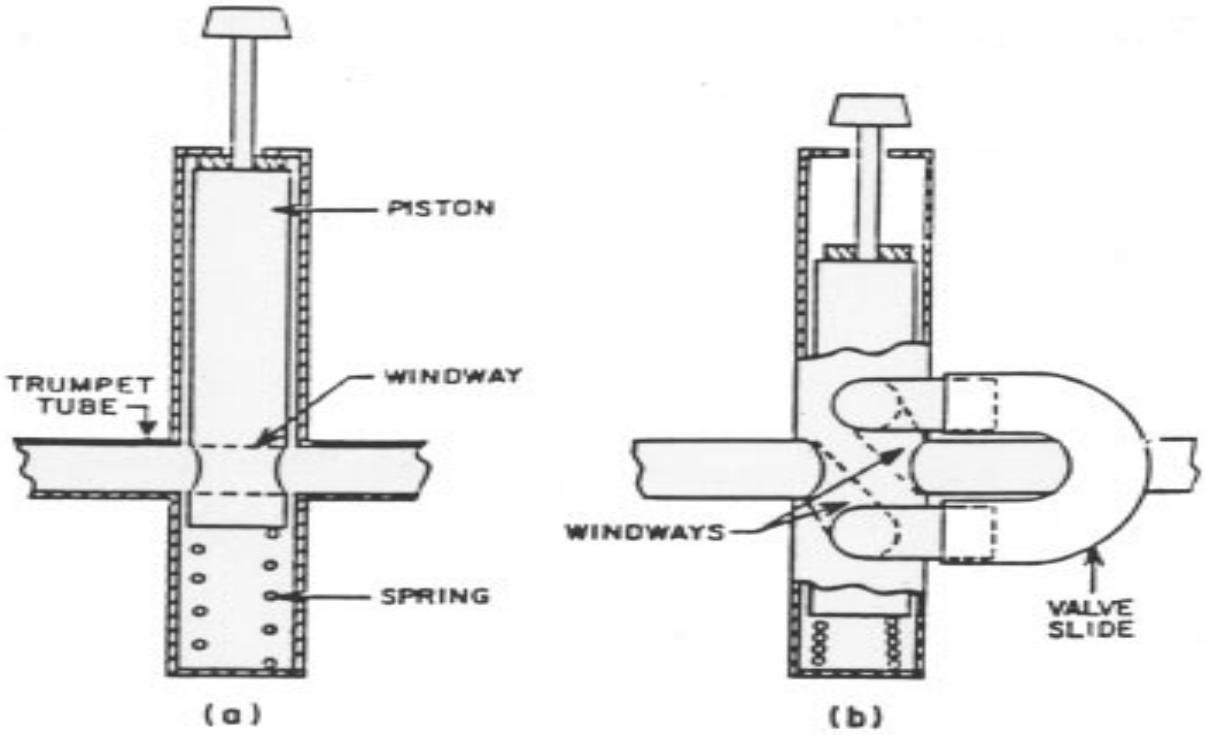


Figure 12.22 : The evolution of a trumpet : effects of the mouthpiece and bell

(a) Resonances in a simple tube.

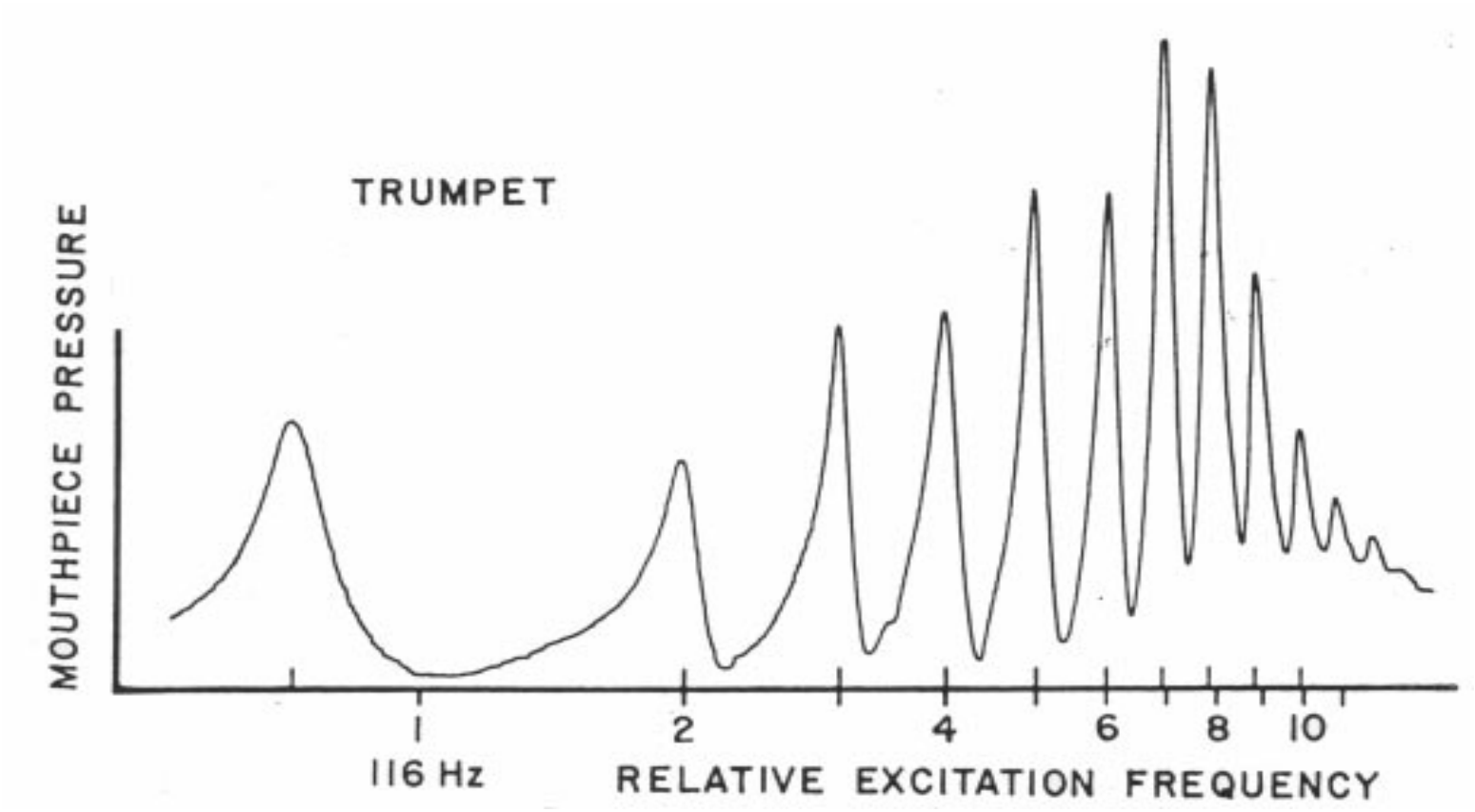
(b) Resonances in a tube with a mouthpiece.

(c) Resonance in a trumpet.



Structure of a trumpet valve. (a) Piston up. (b) Piston down.

Figure 12.24: Trumpet valve


TRUMPET
MOUTHPIECE PRESSURE
1
116 Hz
2
4
6
8
10
RELATIVE EXCITATION FREQUENCY

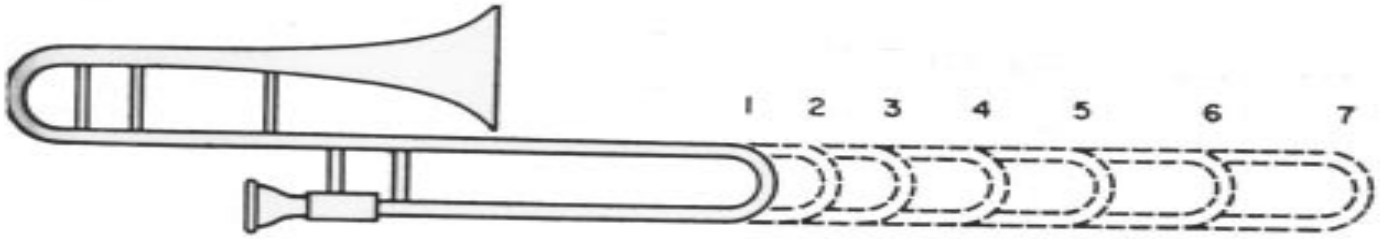
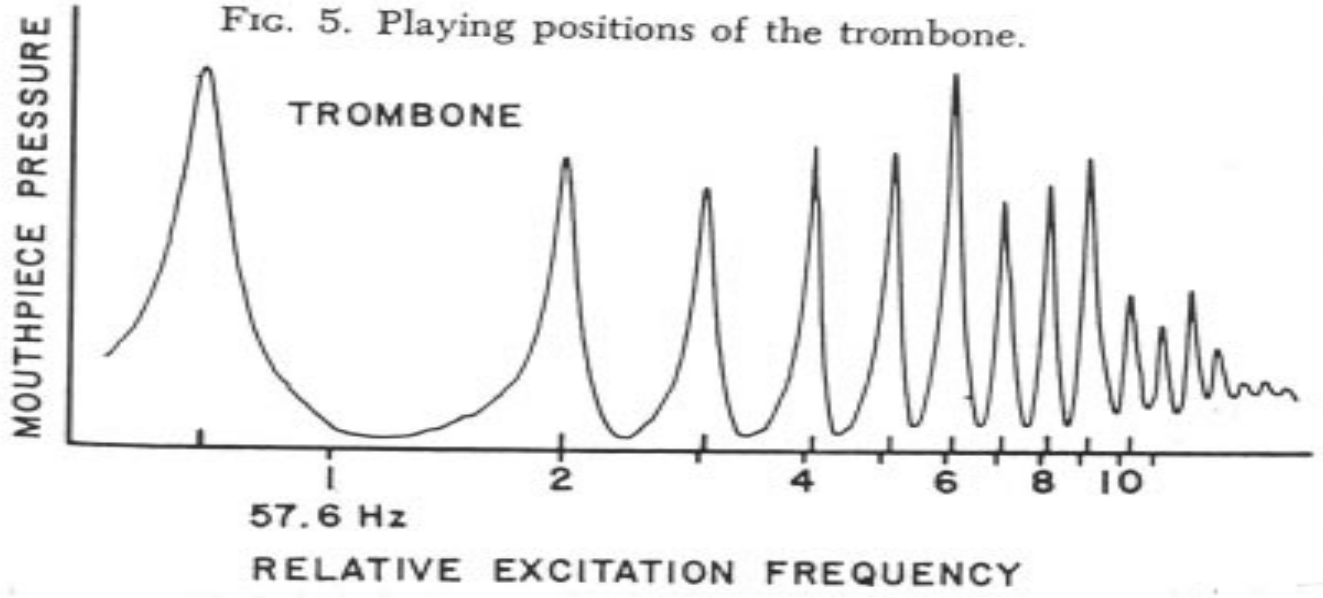
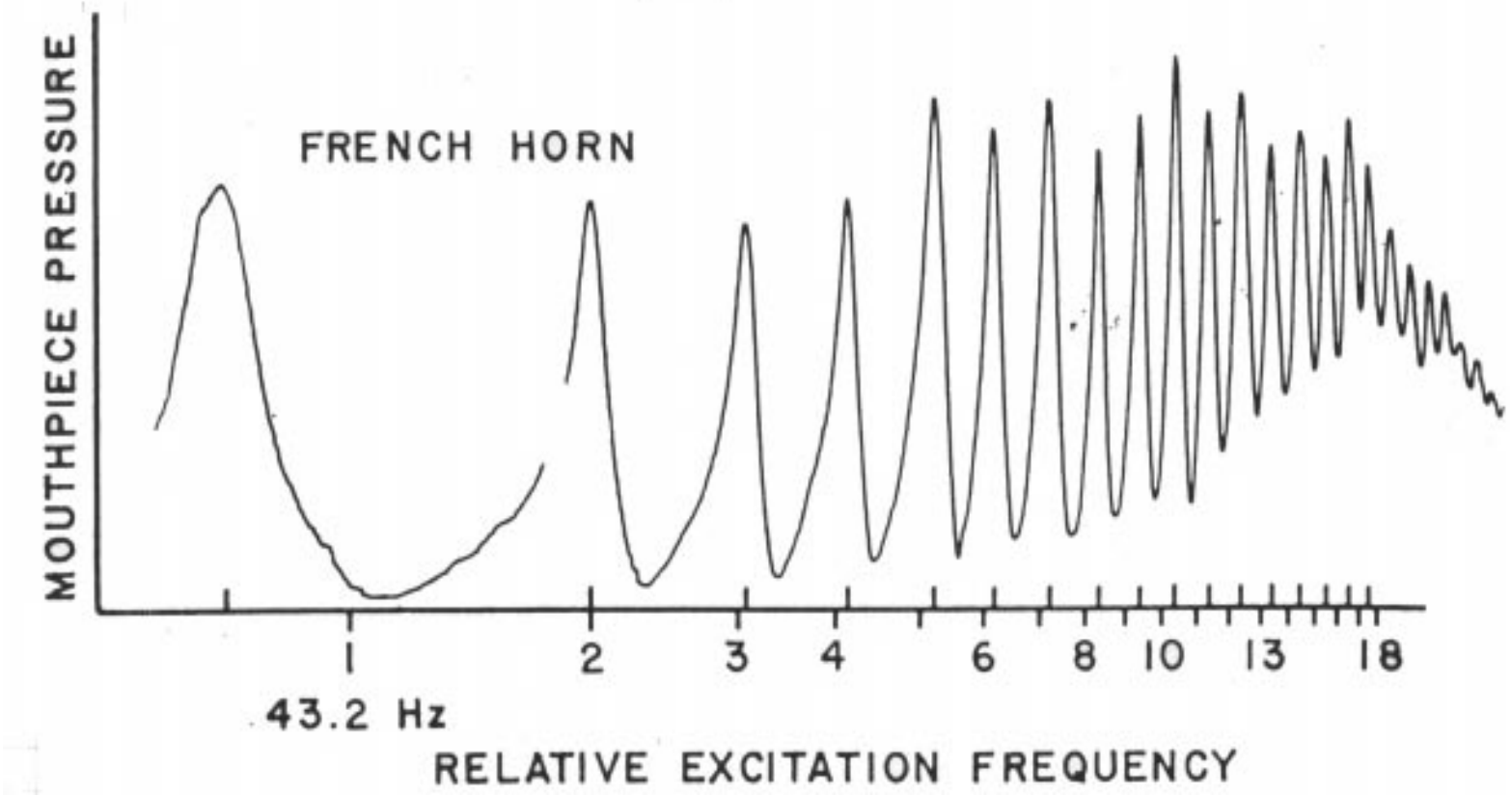


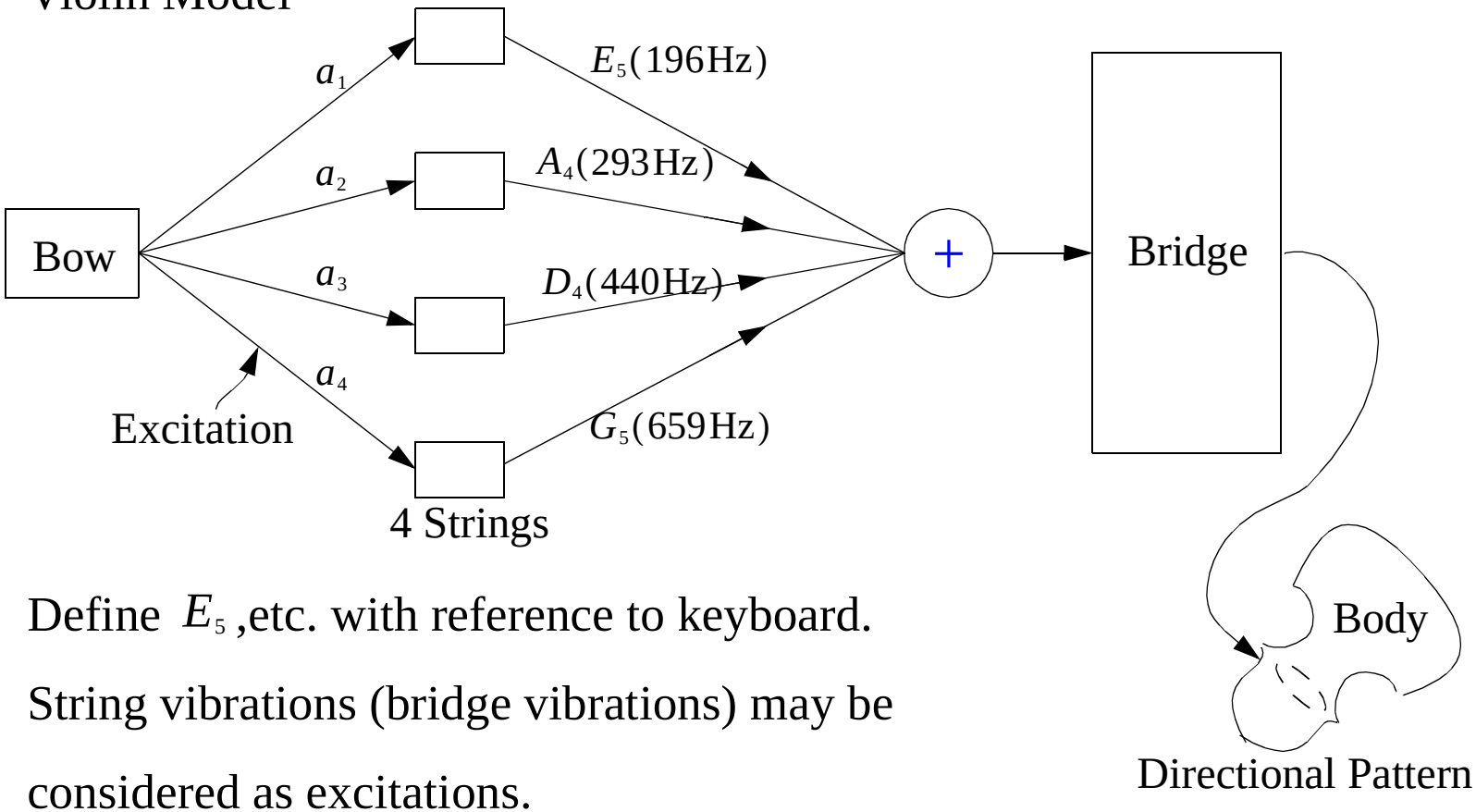
FIG. 5. Playing positions of the trombone.




FRENCH HORN
MOUTHPIECE PRESSURE
1
2
3
4
6
8
10
13
18
43.2 Hz
RELATIVE EXCITATION FREQUENCY

Violin : (Cellos, Violins, etc.)

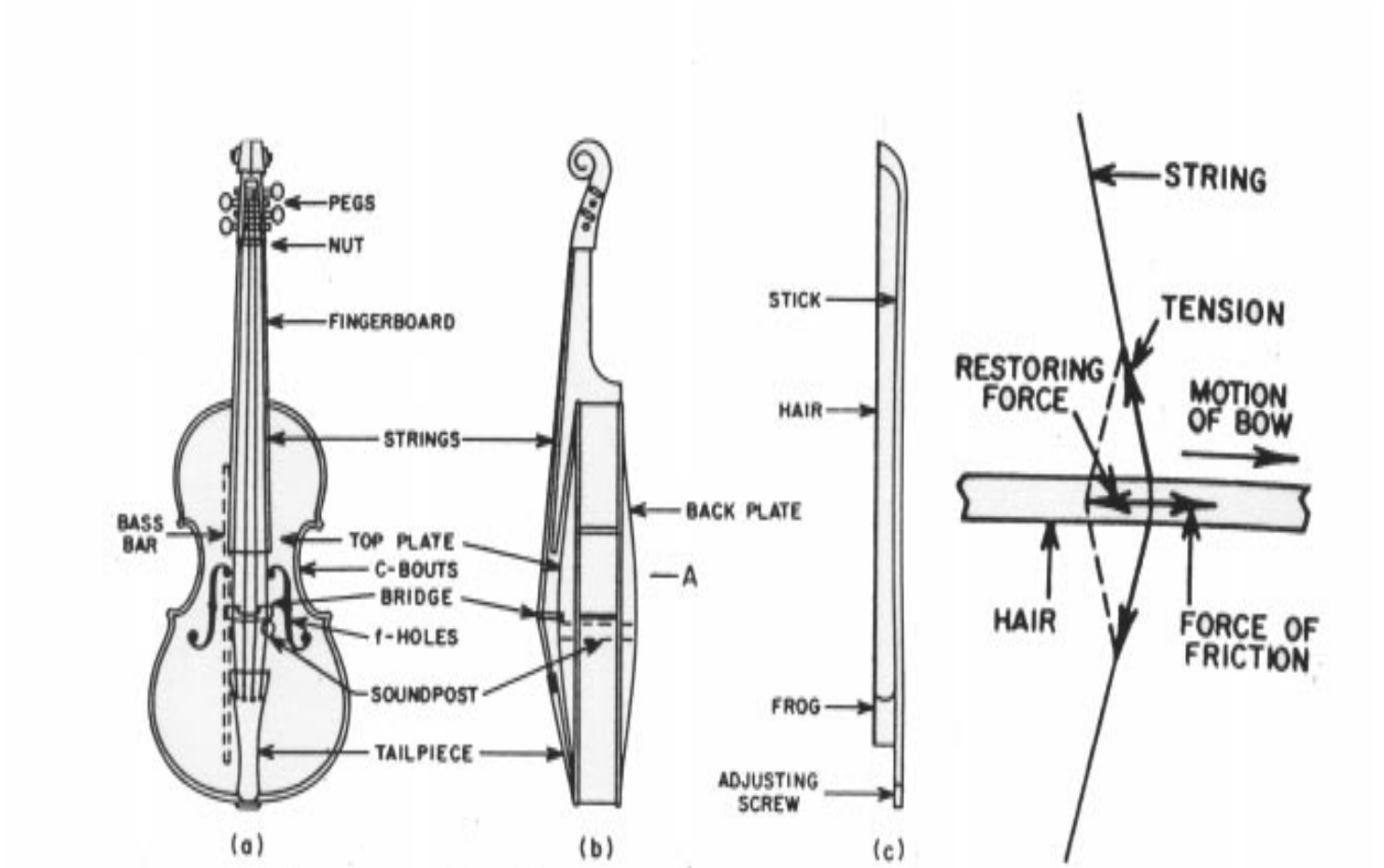
Violin Model



Define E_5 ,etc. with reference to keyboard.

String vibrations (bridge vibrations) may be considered as excitations.

So it's different than the trumpet [violin has several excitions].



(a) Front view of a violin. (b) Side view. (c) Bow.

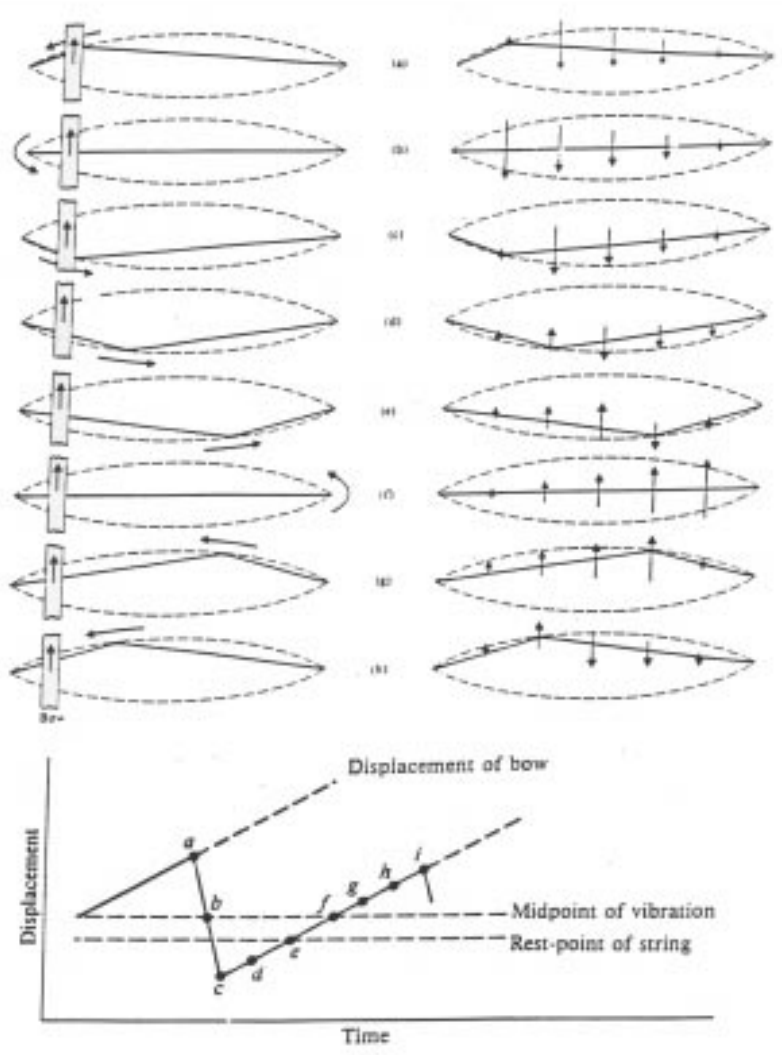


Figure 12.2: String state vs. string displacement at point of bow contact

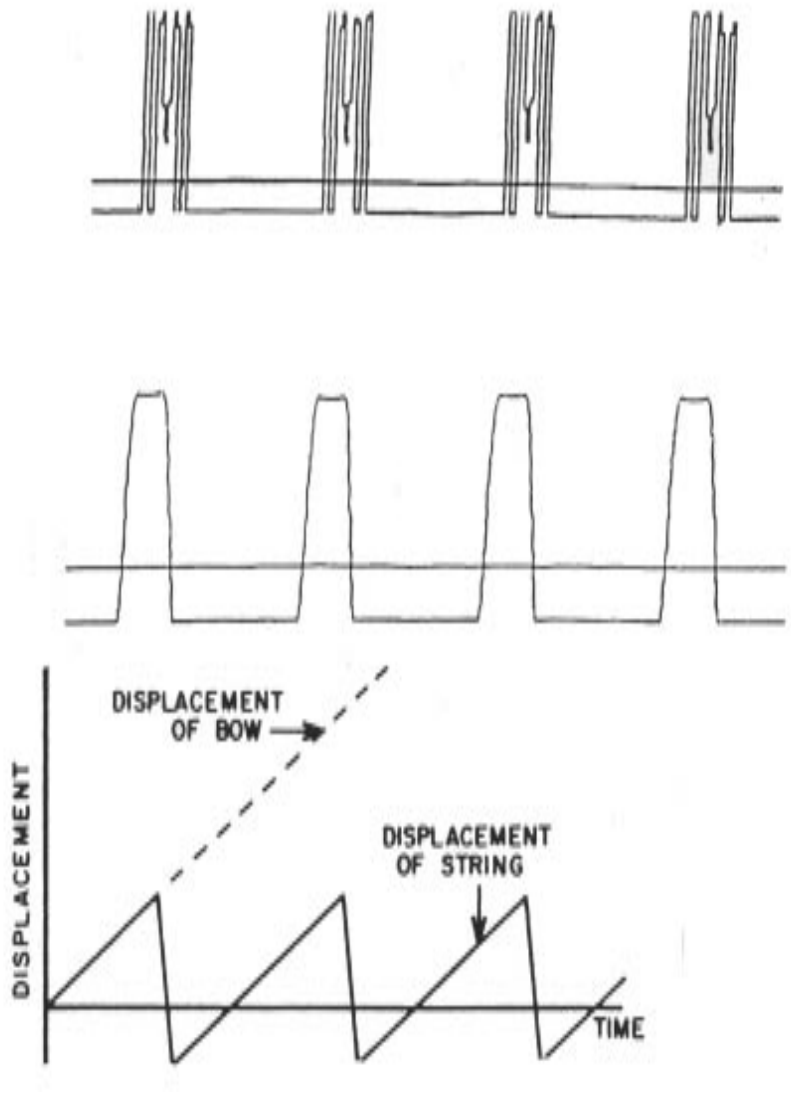


Figure 12.3: "Good" and "**B**ad" string velocity at the bowing point

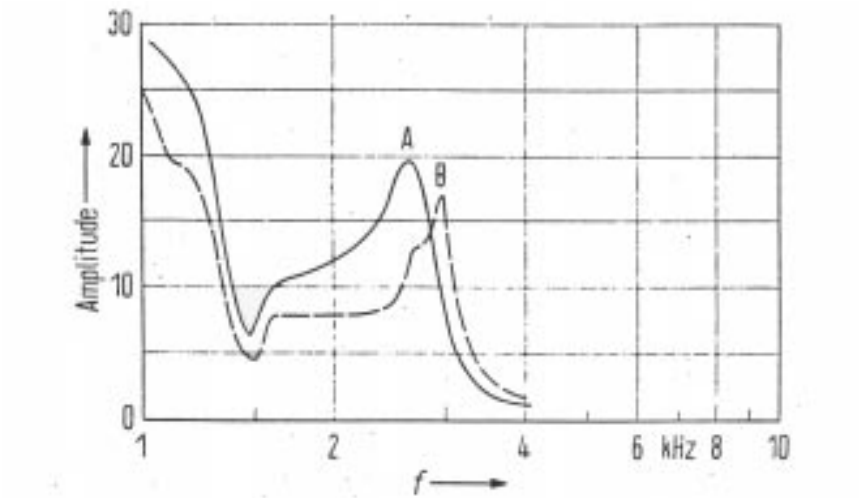


Figure 12.5: Bridge A (mellow) and bridge B (brilliant) frequency response curves

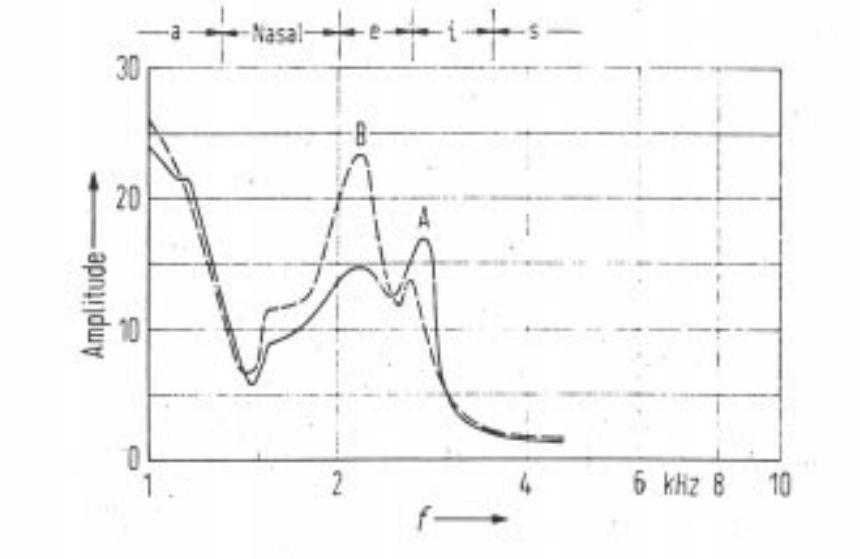
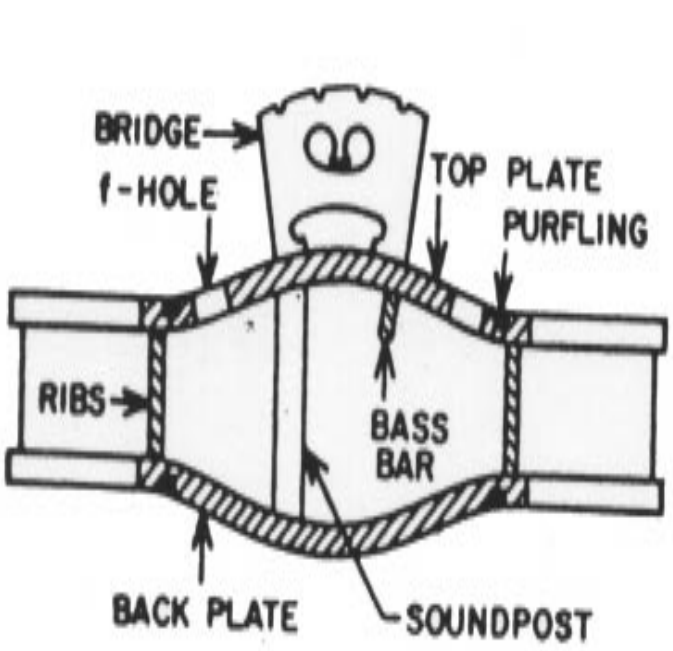
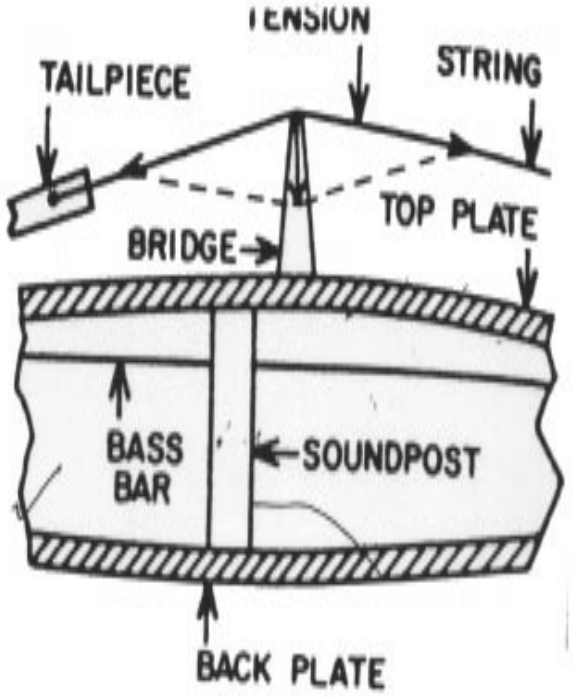
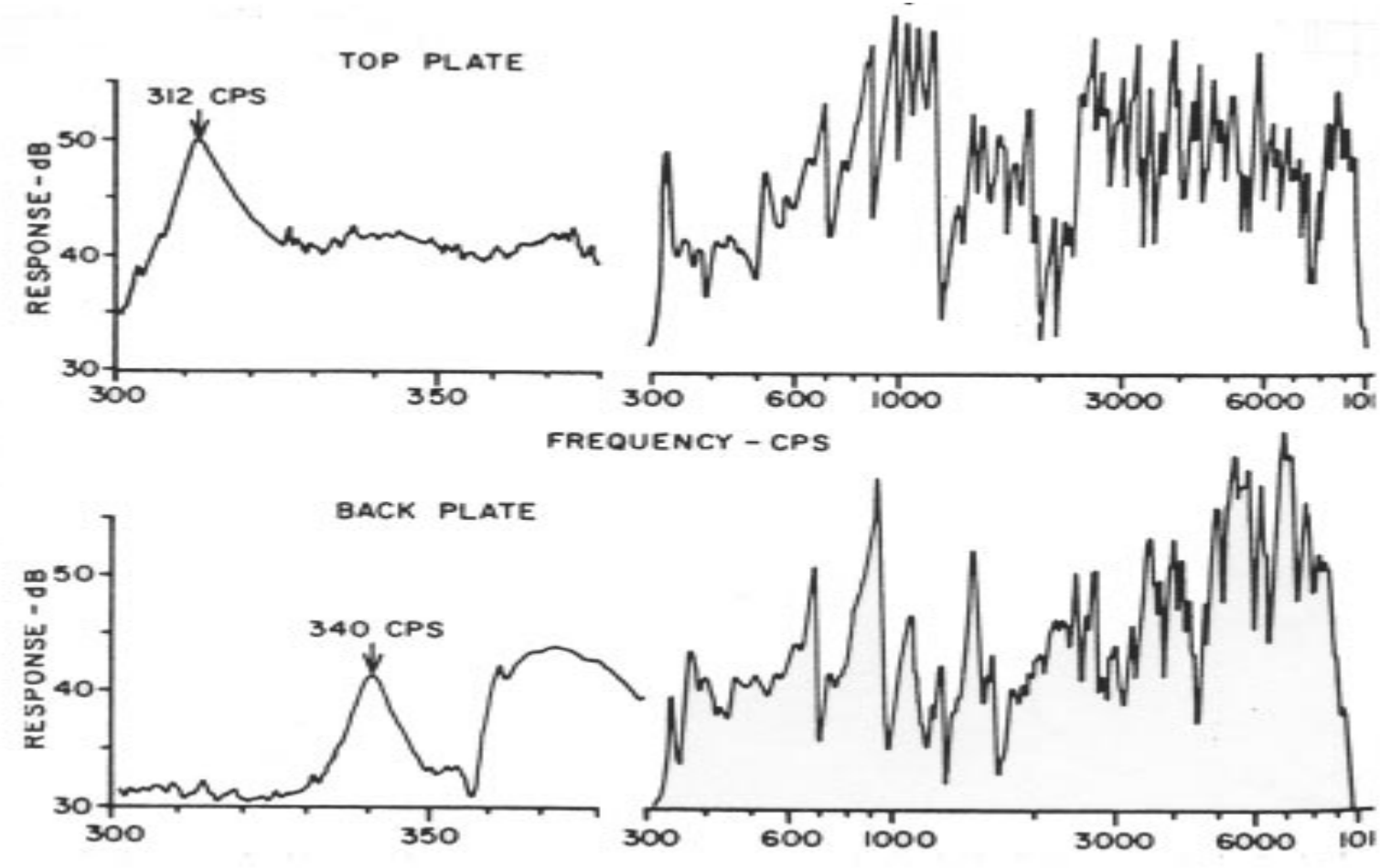


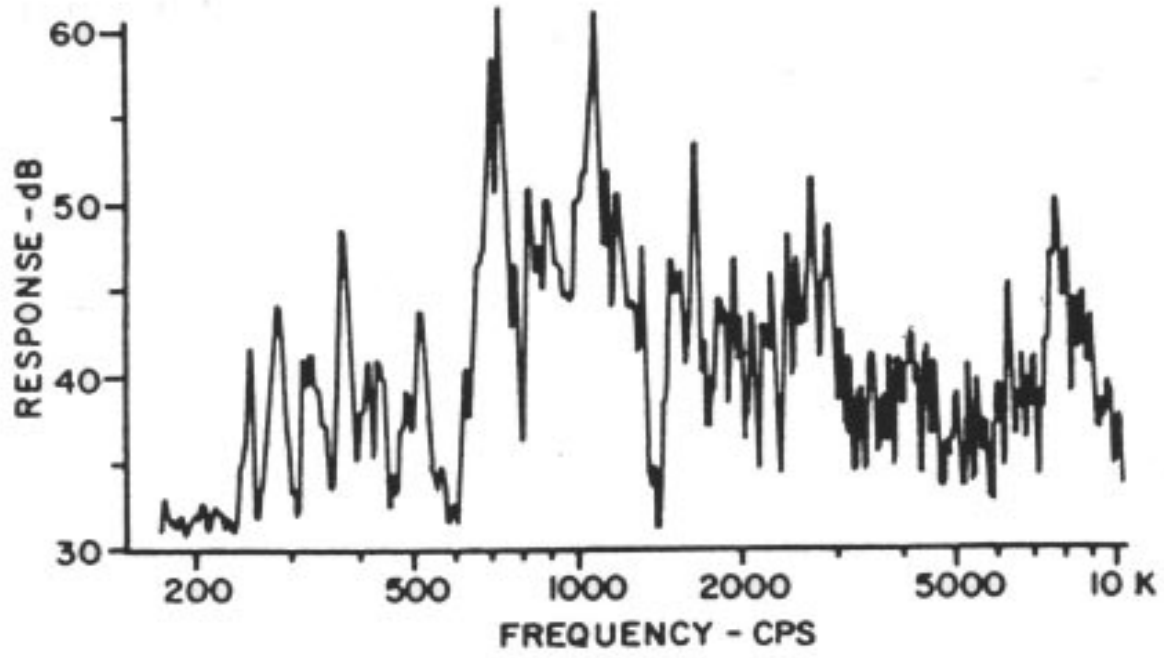
Figure 12.6: Bridge A (original) and bridge B (reduced cross section) frequency response curves


BRIDGE
f-HOLE
TOP PLATE
PURFLING
RIBS
BASS BAR
BACK PLATE
SOUNDPOST


TENSION
TAILPIECE
STRING
BRIDGE
TOP PLATE
BASS BAR
SOUNDPOST
BACK PLATE

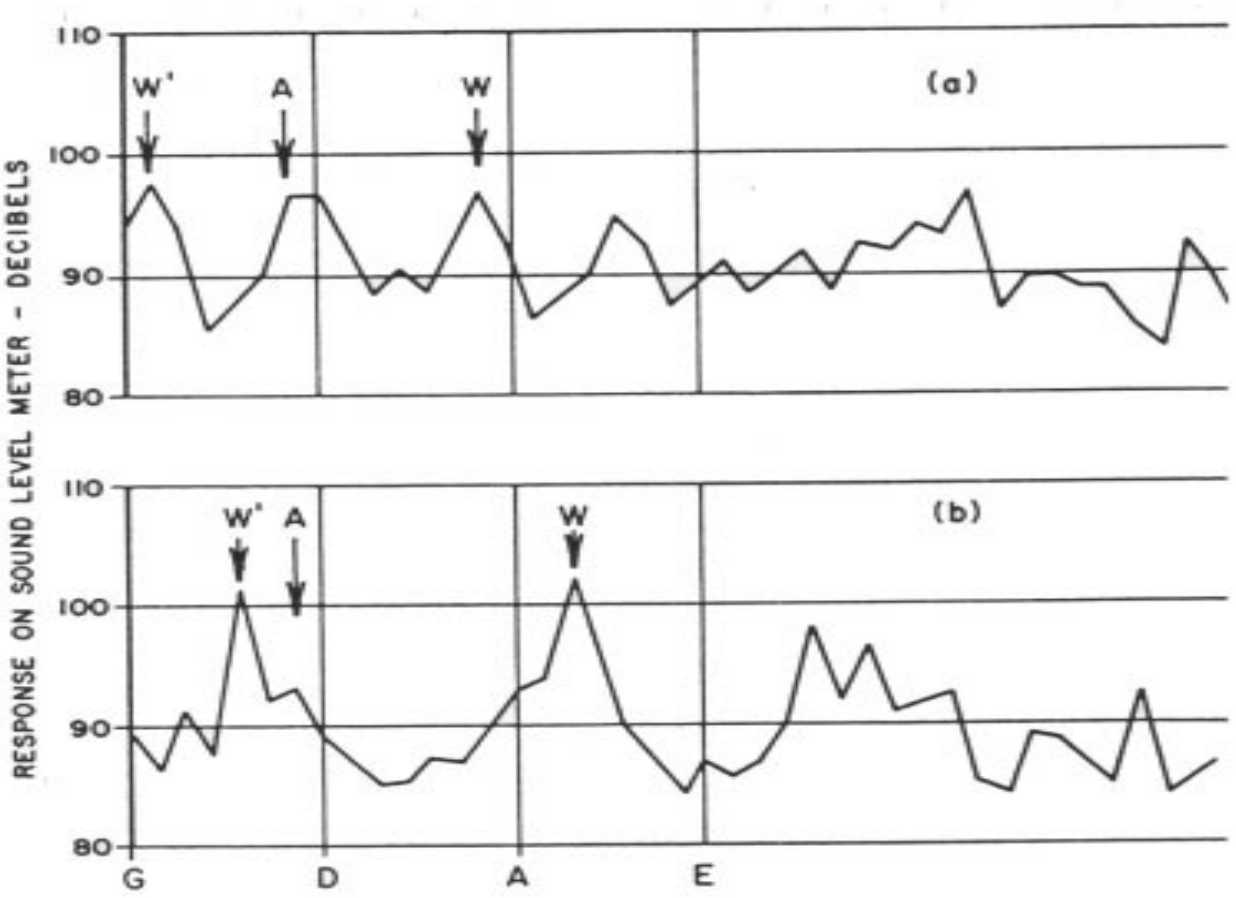


Resonance Curves



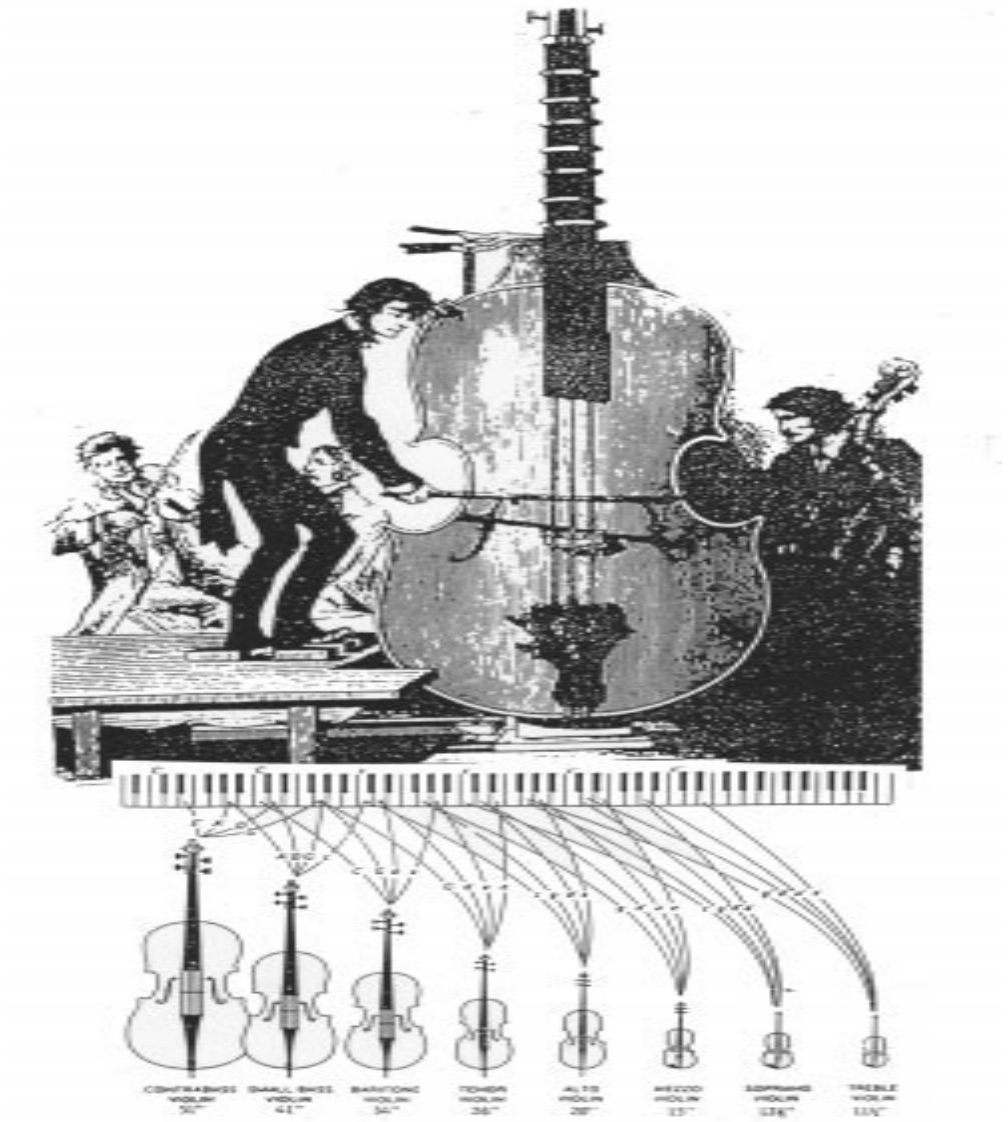
Response curve for a violin assembled from

th two plates whose resonance curves are given



Loudness curves for two violins. (a) A good 1713 Stradivarius violin

(b) A 250-year-old violin of unknown origin



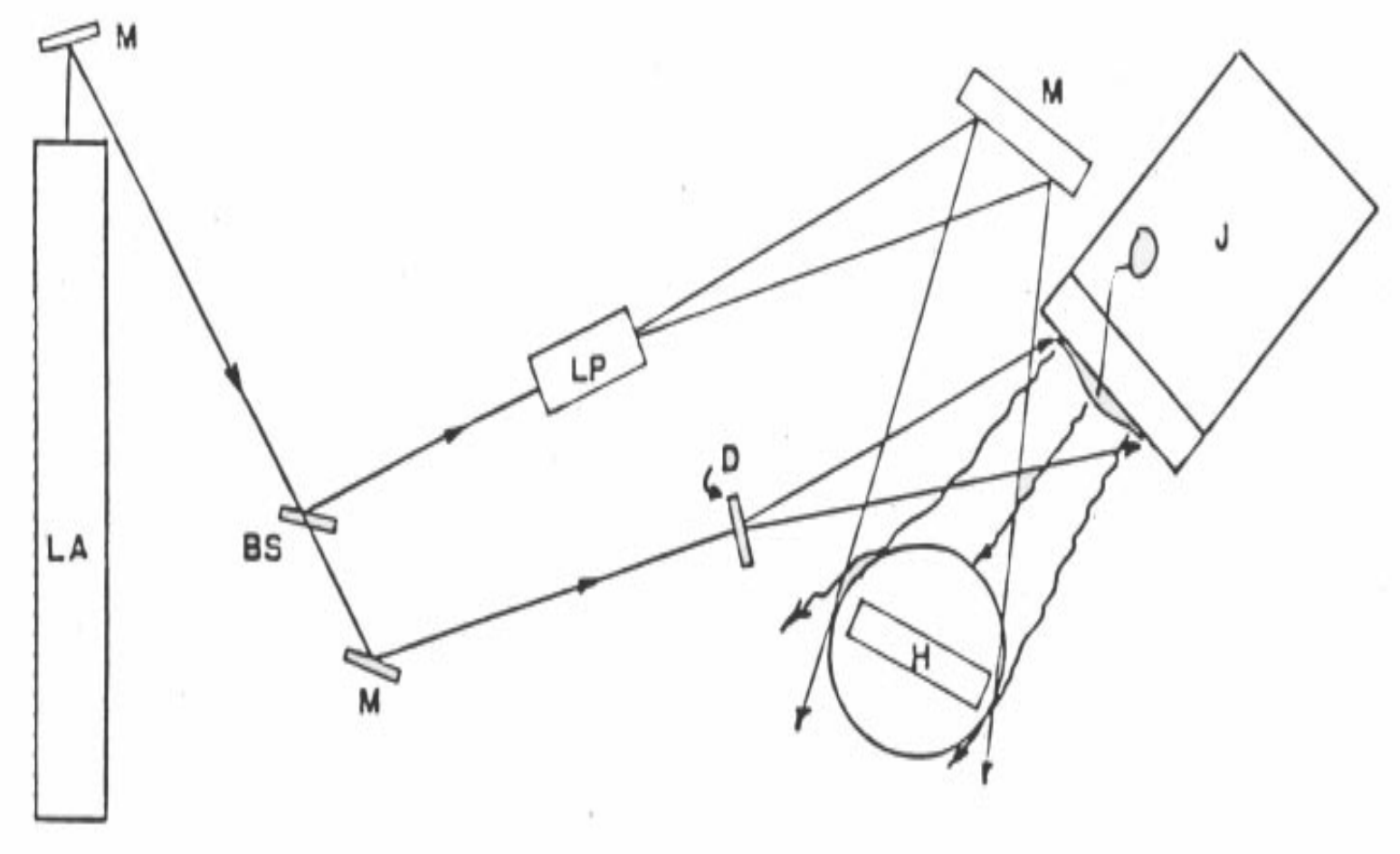


Figure 12.7: Holographic Photography

Holography can measure vibrations of a) Violin bodies,
b) Trumpet, trombone bodies.

- Object H is illuminated by a reference beam and object beam.

$u(x, y)$ is the object beam.

$\upsilon(x, y)$ is the reference beam.

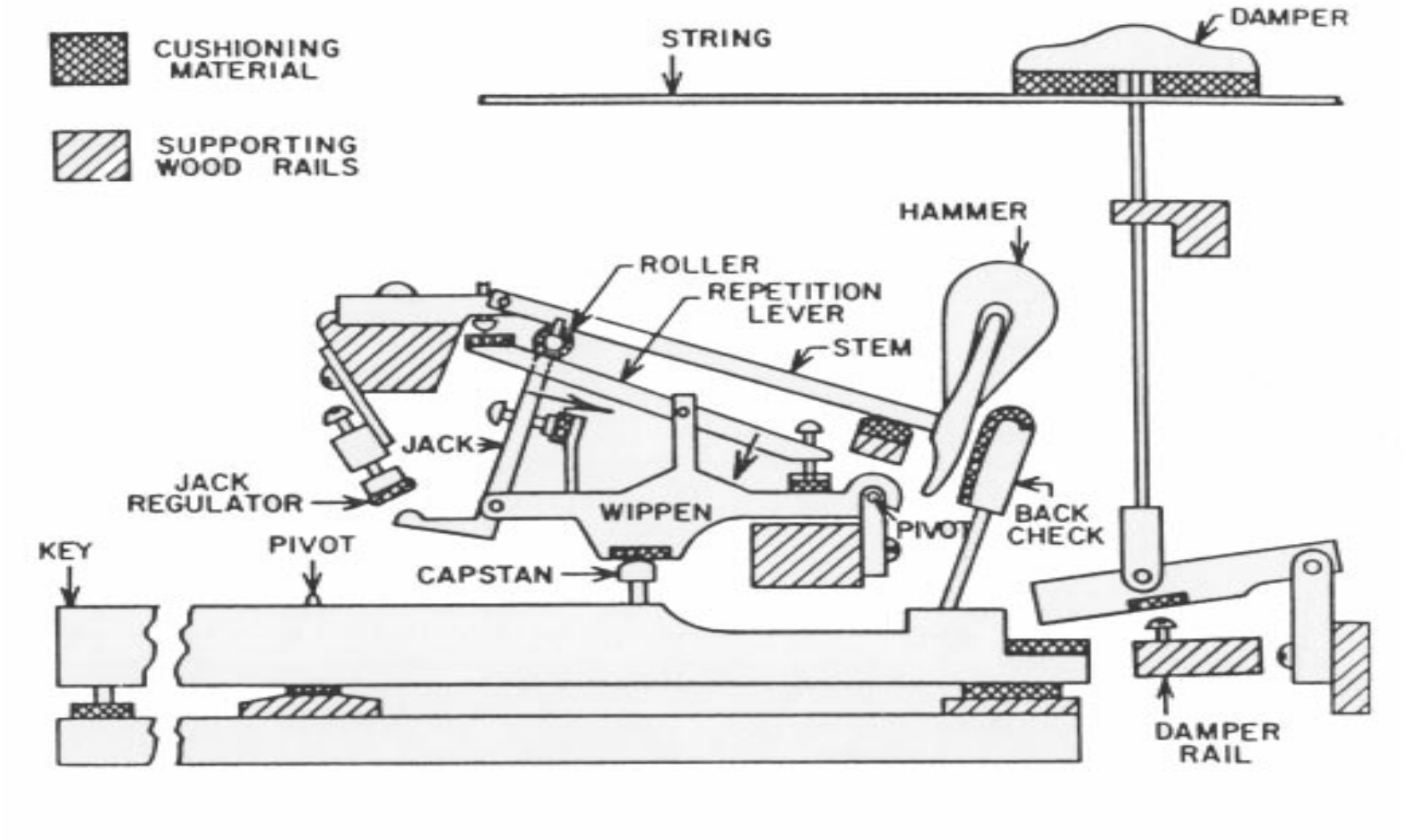
Film: Sees the intensity of the two beams.

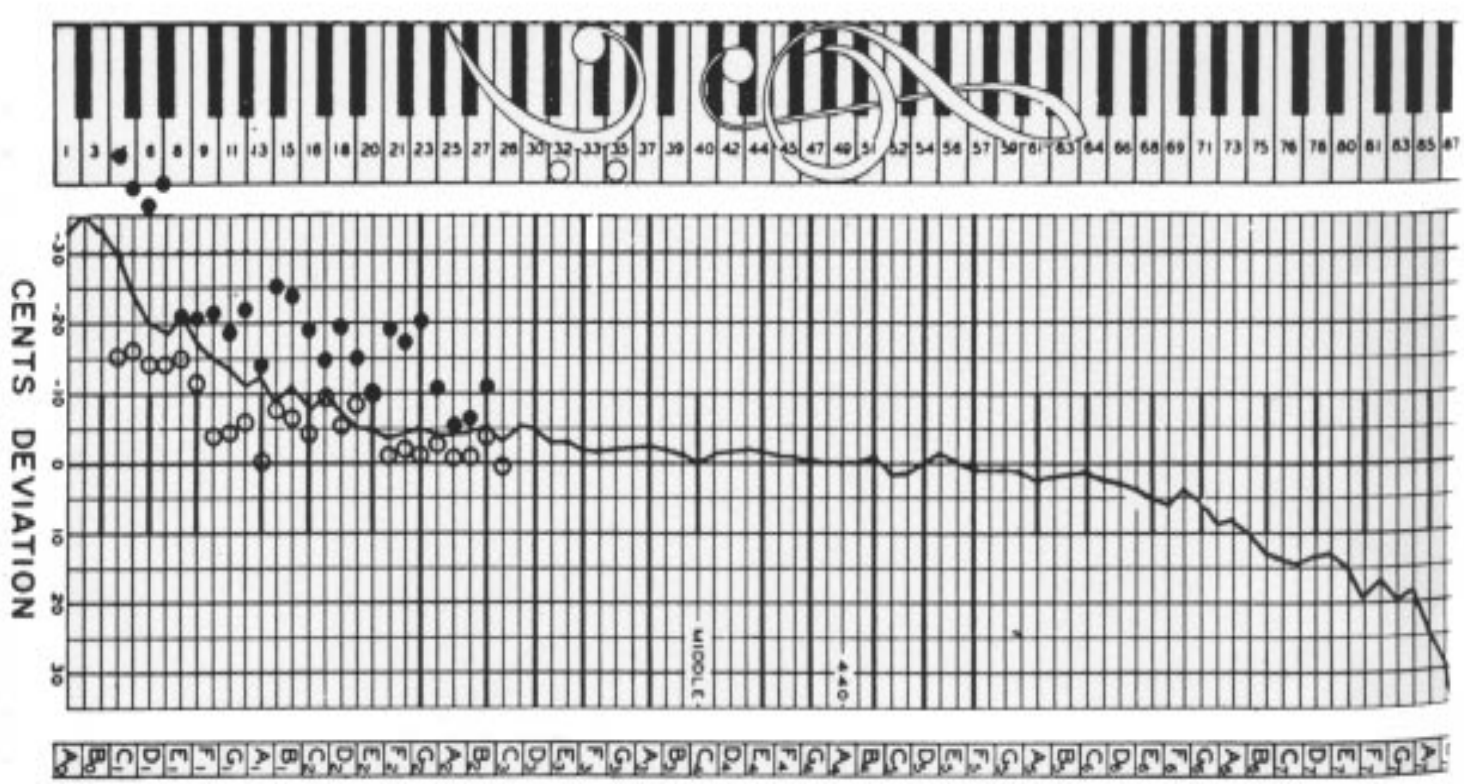
$$(u + \upsilon)(u^* + \upsilon^*) = |h|^2 = uu^* + \upsilon u^* + u\upsilon^* + \upsilon\upsilon^*$$

Now, shine υ through film.

$$\upsilon|h|^2 = \gamma[u^*\upsilon u + \upsilon^2 u^* + \underline{\underline{u\upsilon\upsilon^*}} + \upsilon^2\upsilon^*]$$

If all other terms can be made SMALL,
you see an image (with phase), proportional to $u(x, y)$.


CUSHIONING MATERIAL
SUPPORTING WOOD RAILS
STRING
DAMPER
HAMMER
ROLLER
REPETITION LEVER
STEM
JACK
JACK REGULATOR
WIPPEN
PIVOT
BACK CHECK
KEY
PIVOT
CAPSTAN
DAMPER RAIL


CENTS DEVIATION
-30
-20
-10
0
10
20
30
MIDDLE C
440