The Tuba and the Concerto

An analysis of the *Concerto for Bass Tuba and Orchestra* (1954) by Ralph Vaughan Williams based on the characteristics of the British “Barlow” F tuba

Ivo Lemken
5700515

Eindwerkstuk BA Muziekwetenschap
MU314004
2018-2019 Blok 2
Universiteit Utrecht
Begeleider: Ruxandra Marinescu

Abstract

Since the early twentieth century, the British tuba playing tradition has differed strongly from both the continental European and the American tradition. On June 13, 1954 the first Tuba Concerto, written by Ralph Vaughan Williams, premiered at the last Jubilee concert of the London Symphony Orchestra. The soloist of the premiere, Philip Catelinet, played on a British "Barlow" F tuba. This instrument was a representation of the standard of British tubas playing at this time and since importing foreign instruments was illegal, it can safely be assumed that Vaughan Williams wrote his concerto with this instrument type in mind. In this thesis, the sound of two "Barlow" F tubas is analyzed with the use of chromagrams. The chromagrams - a visual representation of sound separated into twelve pitch classes - support an aural analysis of the sound of these tubas. This analysis shows that both tubas in the case study have a dark and mellow sound with a throaty whisper-like quality in the lower register - corresponding to a strong presence of overtones in the minor seventh chroma. The results of this analysis are used in the music analysis of the score of Vaughan Williams's concerto. This music analysis shows that the composer was aware of the better and lesser qualities of the British F tuba and used a range of methods to accommodate this instrument and highlight its best qualities. Furthermore, evidence in the orchestration points towards the composer viewing the tubas lower range timbre as similar to that of the bassoon.

Table of Contents

The Tuba and the Concerto

An analysis of the *Concerto for Bass Tuba and Orchestra* (1954) by Ralph Vaughan Williams based on the characteristics of the British "Barlow" F tuba

Introduction

The big brass instrument, right? The most common reaction among people without a musical background does not seem very bright, but it is actually a good start to defining what a tuba is. From large sousaphones to *Small French Tubas in c*, from the *Subkontrabasstuba* to the *Kaisertuba*, the Cerveny *Kontrabasstuba* and the original *Basstuba* created by Moritz and Wieprecht in 1835, the variety of tubas seems never-ending, making it hard to give one single definition of the instrument.[1] Even in modern day practice with standardized factory processes, the variety is enormous. With conventions differing from nation to nation, it is not uncommon for a professional tuba player to own four or more different tubas and a cimbasso.[2] This is not usually a set of F, Eb, C and Bb, but rather a set of several F and C tubas (where F might be replaced by Eb and C by Bb depending on regional conventions) with different shapes and sound. This might seem counterintuitive, but it is historically founded upon the first *Basstubas* - developed by Moritz and Wieprecht in 1835 - being F tubas and the first *Kontrabasstubas* - developed by Cerveny in 1845 - being C-tubas. [3]

[1] All tubas named here were developed in the nineteenth century. A detailed discussion of all these instruments can be found in Clifford Bevan, *The Tuba Family* (Winchester, UK: Piccolo Press, 2000).
[2] The cimbasso is a contrabass valve trombone. Its mouthpiece is the same size as a tuba mouthpiece and it is known. Historically the name cimbasso has been used for several other instruments. For an overview see Bevan, *Tuba Family*, 406-425.
[3] The information on the organology of the tuba is based on Bevan, *Tuba Family*, 275-425. I rely on these two chapters on the organology of the tuba in the next 2 paragraphs.

Figure I.1: One of the first *Basstubas*, built by C.W. Moritz 1835-1840[4]

The tuba is an instrument to be taken seriously and has been regarded as such by major composers directly after the first models came to the market. Richard Wagner and Nikolai Rimsky-Korsakov were influential in giving the tuba its standard position in the symphony orchestra; their students and successors started using the tuba more and more and at the beginning of the twentieth century, the first tuba solos appeared in symphonic music.[5] During the 1920's the first solo tuba works appeared and in 1954 the first-ever and most famous tuba concerto was written by Ralph Vaughan Williams.[6] It was regarded as highly virtuosic at the time and it has now become the most important in the tuba repertoire. After this tuba concerto was written, the level of tuba playing has changed rapidly becoming more virtuosic. New repertoire was created and tuba players even went into performing virtuoso pieces that were originally written for string instruments.

[4] Though the length of the tubing of this *Basstuba* is equal to that of contemporary F tubas, the instrument is much smaller due to its smaller bell and bore size.
Photo: Hans Skoglund. Source: "Tuba," Skenkonst Museet and Musical Instrument Museums Online, accessed January 15, 2018, http://www.mimo-international.com/MIMO/doc/IFD/OAI_SMS_MM_POST_478.

[5] It is often assumed that Wagner used the tuba as a solo instrument in passages that are also played by the basses. However, accounting for the smaller size of tubas in Wagner's time period, the tuba and the bass group probably played at a similar dynamic level.

[6] Ralph Vaughan Williams, *Concerto for Bass Tuba and Orchestra* (Oxford, UK: Oxford University Press, 2012).

There is a vast variety in national traditions for tuba playing, which is most easily spotted in Great Britain, where the traditional German design with a left facing bell and rotary valves was replaced by one with a right facing bell and top piston valves.[7] Though the direct reason for this shape is unclear, this tradition started with the commission of one specific instrument in 1887 by Hans Richter for J.H. Guilmartin. The design by William Hillyard of London followed the pattern of either the Eb saxhorn-shaped tuba or the euphonium. A similar shape was used in the Higham F tuba ordered by Harry Barlow in 1896-1897. This became the inspiration of all so-called "Barlow" F tubas which would become the standard in British orchestral playing until the 1950's.

It is not surprising that Philip Catelinet used a "Barlow" F tuba in the 1954 premiere of Vaughan Williams's Tuba Concerto with the London Symphony Orchestra conducted by Sir John Barbirolli at the Royal Festival Hall in London. There were probably only few - if any - German style tubas available in Britain at that moment and it is unlikely that Catelinet and Vaughan Williams even considered the use of a German F tuba for this piece.[8]

My thesis addresses the characteristics of the British "Barlow" F tuba and how Vaughan Williams might have used these special characteristics in his concerto. My study focuses on which elements in the score point towards knowledge and usage of these characteristics.

To enable a fair analysis of the sound– by this I mean going further than subjective verbal descriptions – I have created chromagrams, a sound visualization method commonly used in the analysis of timbre in computer sciences. The chromagrams are created for the cadenzas from two existing recordings of the Vaughan Williams Tuba Concerto performed by Philip Catelinet and the London Symphony Orchestra conducted by Sir John Barbirolli recorded on the June 14, 1954 and more recently by Arnold Jacobs and the Chicago Symphony Orchestra conducted by Henry Mazer, recorded at two live performances on October 26 & 28, 1978. [9]

---

[7] When mentioning German tubas in this thesis, I mean to not only refer to tubas with a left facing bell and rotary valves (or in the earliest models Berliner Pumpen) built in Germany, but also similar models created around the world, including American tubas with front-facing valves.

[8] The possibility of the Vaughan Williams thinking about performances abroad exists, but his first and foremost market was the British one.

[9] Ralph Vaughan Williams, "Concerto for Bass Tuba and Orchestra," with Philip B. Catelinet and the London Symphony Orchestra, conducted by Sir John Barbirolli, recorded June 14, 1954, Google Play Music, track 4-6 on London Symphony Orchestra, *Vaughan Williams: Oboe Concerto*, 2000.
Available via Youtube, accessed January 15, 2019, https://www.youtube.com/watch?v=i9Rkaz1v5GI.
Ralph Vaughan Williams, "Concerto for Bass Tuba and Orchestra," with Arnold Jacobs and the Chicago

With the help of these chromagrams, I will analyse the sound characteristics of the British “Barlow” F tuba, which is used in both recordings. I will not look at the metrics of the instrument, bore and bell size, even though I believe that the tubing of British tubas - that have more cylindrical, and therefore less conical, tubing than German tubas - has a large impact on the sound.

I will use the knowledge about these characteristics in my music analysis of Vaughan Williams's Tuba Concerto. In this analysis, I will focus on the elements in the score that indicate choices made by the composer based on the timbre and other special characteristics of the British F tubas.

The results of this analysis will show that the analysed British “Barlow” F tubas have a distinct sound that differs from German Tubas mainly in the lower range of the instrument. The British “Barlow” tubas have a whisper-like, throaty quality - corresponding to a strong presence of minor seventh overtones - in the lower range. Both performers in the selected recordings seem to have difficulty in keeping low notes stable.

The music analysis will show that Vaughan Williams was aware of the better and lesser qualities of the tuba. The analysis will show that he wrote his tuba concerto specifically for British F tubas in such a way that he highlights the best performing qualities of this instrument.

This thesis is not a plea to perform the Tuba Concerto by Vaughan Williams only on a British (“Barlow”) F tuba, but it should endorse a closer look at the score in order to see where the composer might have intended to help the soloist.

Symphony Orchestra, conducted by Henry Mazer, recorded October 26 & 28, 1978, track D2 on Chicago Symphony Orchestra, *From The Archives Vol.2 : Soloists of the Orchestra*, CSO 87/2, 1987.
Available via Youtube, accessed January 15, 2019, https://www.youtube.com/watch?v=WLg42fTu_2o.

Chapter 1: The use of chromagrams in the analysis of timbre and the history of British tubas

Chromagrams in the analysis of timbre

A chromagram, like a spectrogram, is a visual representation of the loudness of the frequencies that build up a sound. The special characteristic of a chromagram is that the loudness of all notes that fall into the same pitch class (chroma) is added up, leaving us with only 12 variables. This simplification of the original sound might seem radical, but is based on the fact that humans perceive tones of the same chroma as very similar, even if they are in a different octave. Another important factor in the human perception of sound is that we are very perceptive of overtones. In fact, it is one of the most important factors in our perception of timbre. Although the loudness of these overtones is usually quite low, we can easily distinguish small changes.[10] Therefore, when creating a visual chromagram for timbre analysis, it is common to use a logarithmic scale, which is more perceptive to small changes. This results in an easily readable model that is very perceptive of differences in tone quality.

Chromagrams are mostly used in computer sciences as a versatile method for the analysis of music. They have been proven effective for many different applications in musical information retrieval. Though mostly used in the retrieval of tonal content (e.g. chord recognition), recent studies by Ezzaidi et al. have shown very promising results in the use of chroma features as a method of analyzing timbre.[11] Contrary to common practice in computer sciences, I will not use a computer for automated processing of the data conveyed in the chromagram, but I will interpret the chromagrams myself and use them to support the aural analysis of the sound of these two instruments.

It should be noted that the analysis of the sound of a tuba is a complicated objective because of several reasons. The choice of a mouthpiece can have a major impact on the sound

[10] For example: When we talk to somebody over the phone, frequencies outside of the average range of human voice are cut off for performance purposes. Although we can still understand everything the other person is saying, everybody can relate to the feeling of not recognizing the other person's voice.

[11] Hassan Ezzaidi, Mohammed Bahoura, and Glenn Eric Hall, “Towards a Characterization of Musical Timbre Based on Chroma Contours,” *Advanced Machine Learning Technologies and Applications*, ed. Aboul Ella Hassanien, Abdel-Badeeh M. Salem, Rabie Ramadan, and Tai-Hoon Kim, (Berlin: Springer, 2012), 162–71.

of an instrument and the player has an even bigger one. Furthermore, recent work by Arnold Myers has shown that the use of a valve has a larger influence than the size of an instrument has on the sound that the instrument produces.[12] However, from a player's perspective, every tuba has its own characteristics and the challenge is to find the ideal sound of an instrument. In the process of playing, a performer compensates for the effect that the use of valves has on the sound and the performer might even use different valve combinations to create the ideal sound in a given situation. Next to all these factors, due to the size of the tuba, even the air pressure and temperature around the bell has a large impact on the sound.[13]

From a purely scientific viewpoint, a fair analysis of specimen with so many factors affecting the outcome is almost impossible. However, from the perspective of a musician, it is everyday practice. It is fundamental to understanding the discussion in this thesis that we view the sound of the instrument not as the result of a thousand variables, but as the outcome of what a skilled player feels the instrument should sound like.

The birth of the British F tuba

Before the analysis of the sound of the British "Barlow" F tuba, a brief overview of the history of the British tuba tradition is necessary. For a long time the British orchestral low brass section was very similar to the French one. Both countries did not switch from ophicleïde to a member of the tuba family until the end of the nineteenth century and when they did, the French favored the small French C tuba, which was pitched an octave higher than the German one, and the British favored the euphonium in Bb. In military bands, Eb Bombardons were also common. [14]

The tradition of the British F tuba was started by Hans Richter, who, as music director of the Viennese Opera, also commissioned in 1875 what was to be the prototype of the Viennese Concert Tuba. After moving to Britain and becoming the principal conductor of the

[12] While playing a brass instrument, the mouthpiece only creates a buzzing sound. It is the form of the tube of the instrument that strengthens certain frequencies more then others, creating the "rich" sound of a brass instrument. Arnold Myers uses the term "spectral enrichment" to define this process and has used the BIAS hardware and software package, to measure this spectral enrichment in several instruments.
Arnold Myers, "The Typology and Timbre of the Tuba," in *Proceedings of the 41st Academic Conference and 33rd Symposium on Musical Instrument Making From the serpent to the tuba: Development and use of low lip-vibrated wind instruments with holes and valves* (Blankenburg (Harz), Germany: Kloster Michaelstein, forthcoming).
[13] Bevan, *Tuba Family*, 29-62.
[14] The information in this paragraph is drawn from Bevan, *Tuba Family*, 371-405. I draw on this chapter on the history of the tuba playing traditions in Britain in the next two paragraphs

Hallé Orchestra in Manchester, he commissioned another tuba with William Hillyard in 1887, to be played on by J.H. Guilmartin, a leading British euphonium player.

a)  b) 

Figure 1.1: a) British "Barlow" F tuba, ca. 1931, built by Besson.[15] When this tuba is played, from the performer's perspective the bell faces right. b) German F tuba, 1882-1912, built by M. Wolff of Oldenburg[16] When this tuba is played, from the performer's perspective the bell faces left. Models based on the principles used in this instrument are the contemporary standard for solo performances.

Looking at the intended player, it is not surprising that Hillyard chose to create an instrument with top piston valves and a right facing bell - much like the euphonium. Shortly after Guilmartin was succeeded as tuba player of the Hallé Orchestra in Manchester by Harry Barlow in 1894, a similar F tuba was commissioned with the instrument maker Higham of Manchester. Throughout his life, Barlow commissioned several other similar F tubas with different instrument makers. These instruments would later be known as "Barlow" F tubas and would become the standard of British tuba manufacturing. The British F tuba tradition was

[15] Photo: Antonia Reeve. Source: "Tuba, Nominal Pitch: F. : Besson," The University of Edinburgh: Musical Instrument Museums Museum Edinburgh, accessed January 17, 2018, https://collections.ed.ac.uk/mimed/record/17988.

[16] Source: "Tuba, Nominal Pitch: F. : M. Wolff," The University of Edinburgh: Musical Instrument Museums Museum Edinburgh, accessed January 17, 2018, https://collections.ed.ac.uk/mimed/record/14940.

cultivated until the 1960's, when British manufacturers decided to stop the production of orchestral F tubas and focus on the production of Eb and Bb tubas for the brass band market instead.

Figure 1.2: A Yamaha YFB-822S, one of the most used contemporary F tubas.
Like most contemporary tubas, it has five valves to enable better tuning.[17]

The first tuba concerto

There is no scholarly discussion of the use of a "Barlow" F tuba for the Tuba Concerto by Vaughan Williams. Arnold Jacobs did make a recording of the piece with the Chicago Symphony Orchestra on a "Barlow" F tuba in 1978, but no discussion followed in both scholarly and non-scholarly publications.[18] However, it is very clear that in the British tuba world of the 1950's, these instruments represented the standard, since importing music instruments was illegal, and it was very unlikely that this piece would have been performed on a German model before the 1960's.[19]

[17] Source: Yamaha Netherlands, accessed January 17, 2019, https://nl.yamaha.com/nl/files/D89A13D9E0CC4BE4B5D0821C690795AF_12073_1056x1746_2f6d0d8ec42a4a0c49d8686ee57ae6e3.jpg.
[18] Brian Frederiksen, *Arnold Jacobs: Song and Wind* (Gurnee, IL: WindSong Press, 2006), 41.
This is also the recording used for the chromagrams
[19] Bevan, *Tuba Family*, 388.

Figure 1.3: Philip Catelinet playing his "Barlow" F tuba for Ralph Vaughan Williams for a press photo (1954)[20]

Vaughan Williams finished writing the Tuba Concerto in 1954. He took great effort in making the piece suitable for tuba and the collaboration with Catelinet resulted in a few changes in the score to make it better suited for this instrument.[21] The first performance of the concerto was at the last concert of the Jubilee of the London Symphony Orchestra on June 13, 1954. Due to this special occasion, the concert received a lot of attention and was recorded the morning after the premiere by His Master's Voice Recording Company.[22]

This concerto is extremely important in the history of the tuba repertoire. The piece is virtuosic and is still the most performed tuba concerto - even though several other concertos were written afterwards, including one by John Williams - and the *New Tuba Source Book*[23] mentions thousands of pieces for solo tuba, almost all written after 1954. One could say that this "break-through" of the tuba was about to happen anyway, but this first concerto from 1954 was at least a catalyst that facilitated the 'emancipation' of the tuba as a solo-instrument.

---

[20] This photograph was originally created to accompany an article about the premiere in Time Magazine published on June 28, 1954. Source: PhilipCatelinet.com, accessed January 17, 2019, http://philipcatelinet.com/wordpress/wp-content/uploads/2014/11/img357-2.jpg.

[21] Bevan mentions added slurs in faster passages indicated in the manuscript. Catelinet mentions how the changes were mutually agreed upon. Bevan, *Tuba Family*, 438. Philip B. Catelinet, "The Truth About the Vaughan Williams Tuba Concerto," *ITEA Journal* 14, no. 2 (November 1986): 31.

[22] Catelinet, "Truth", 32.

[23] Morris, R. Winston, *Guide to the Tuba Repertoire, Second Edition: The New Tuba Source Book* (Bloomington: Indiana University Press, 2006) .

Chapter 2: The tuba sound in Vaughan Williams's concerto

The sound of the “Barlow” F tuba

My analysis in this chapter will be split into a) an analysis of the sound characteristics of the British F tubas, based on the interpretation of chromagrams from two recordings used as case studies and b) the music analysis of the score of the Tuba Concerto by Vaughan Williams based on these characteristics. The first recording was produced the morning after the premiere of the concerto (on June 14, 1954) by Philip Catelinet and the London Symphony Orchestra conducted by Sir John Barbirolli, the second at two live performances on October 26 & 28, 1978 by by Arnold Jacobs and the Chicago Symphony Orchestra conducted by Henry Mazer.[24]

To enable a comparison to present-day standards, I will include chromagrams of the first cadenza performed by Walter Hilgers and Øystein Baadsvik on German tubas. Hilgers played on a modified Alexander F tuba[25], Baadsvik on a Miraphone Eb “Starlight” prototype[26]. These chromagrams will not be analysed and only serve to show how certain characteristics of the “Barlow” F tuba differ from German tubas.

Although nowadays Catelinet might not be regarded as the best performer of this concerto - he sometimes plays out of tune and his faster passages might come across as unpolished - it is extraordinary to have a recording that took place immediately after the premiere, which tells us a lot about the level of tuba playing at the time, even though only through the medium of an audio recording using the technology of 1954.[27] Catelinet used his own “Barlow” F tuba at both the premiere and in this recording.[28]

---

[24] Vaughan Williams, “Concerto for Bass Tuba”, with Philip Catelinet (see Introduction, n.9).
Available via Youtube, accessed January 15, 2019, https://www.youtube.com/watch?v=i9Rkaz1v5GI.
Vaughan Williams, “Concerto for Bass Tuba”, with Arnold Jacobs (see Introduction, n.9).
Available via Youtube, accessed January 15, 2019, https://www.youtube.com/watch?v=WLg42fTu_2o.
[25] Built roughly around 1950, according to Walter Hilgers in an email to the author of this thesis.
[26] In an email to the author of this thesis, Baadsvik mentioned that this tuba was built as a solo instrument and its strongest characteristics include “the flexibility to alter the sound - from clear and bright to dark and mellow, an extremely large - yet manageable dynamic range, fast and precise valve action, clear articulation.”
[27] Playing out of tune does not have a large effect on the resulting chromagrams. It fits to mention that in his time, Catelinet was one of the best tuba players in Britain and his performance of this concerto has inspired many tuba players to reach an even higher level of playing.
[28] Bevan, *Tuba Family*, 385.

The recording by Arnold Jacobs from 1978 gives us another insight. It shows what a more skilled tuba player could produce on a “Barlow” F tuba. Furthermore, Jacobs has been one of the most influential tuba players of all-time performing mostly on American tubas, that follow the German style tubas and most contemporary tuba players were influenced by him. For this recording, Jacobs used a “Barlow” F tuba. Though there is no record of Jacobs stating this, it is generally assumed that his intention was to get closer to the composer’s intention.[29]

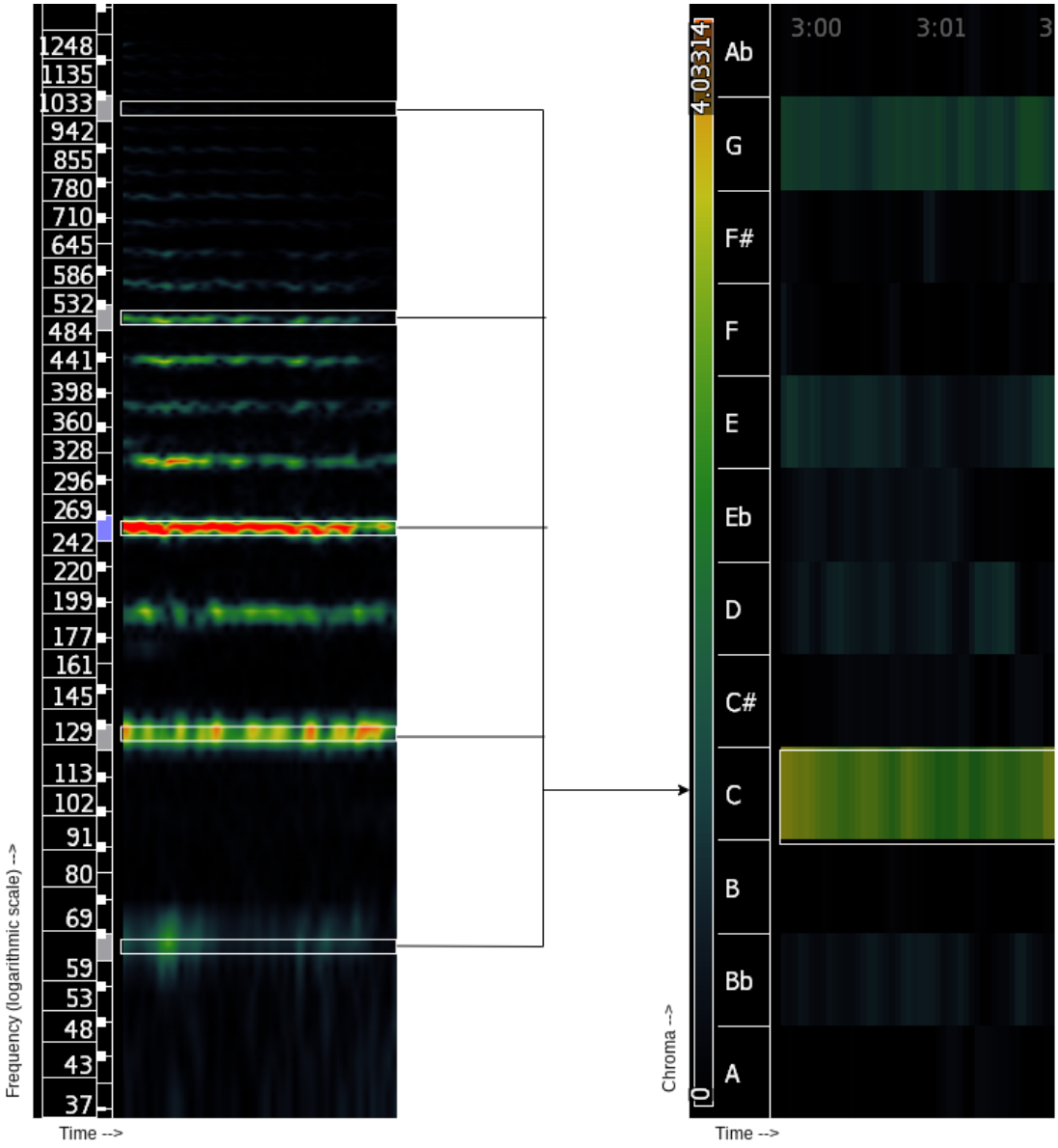


Figure 2.1: Pitch C played by Arnold Jacobs, shown as a spectrogram (left) and a chromagram (right). The values of the C chroma in the chromagram (marked by the white box) are the added values of all frequencies within the chroma (marked by white boxes in the spectrogram) at the same point in time.[30]

[29] Frederiksen, *Arnold Jacobs*, 41. Bevan, *Tuba Family*, 385.
[30] From the recording of Vaughan Williams's Tuba Concerto at 3’00. All pitches are given in the Helmholtz notation system.

As mentioned in chapter 1, chromagrams and spectrograms are both visual representations of the loudness of the frequencies that build up a sound. All spectrograms and chromagrams shown in this thesis are created with the use of Sonic Visualiser and the Chordino plugin. The dynamics of frequencies (for spectrograms) and chroma (for chromagrams) are shown in different colors. Black is the background color, green represents low dynamics (*piano*), yellow a middle range dynamics (*mezzo-forte*) and red represents the highest dynamics (*fortissimo*). It is important to notice that even very low overtone dynamics - shown just by shaded green (*pianissimo*) - are noticeable to our ears.

Spectrograms and chromagrams are created by the use of a Fast Fourier Transform.[31] The FFT decomposes a recorded sound (for example pitch C as in Figure 2.1) into the frequencies that build it up and their dynamics. A spectrogram is a visualization of these values without further processing, such as in Figure 2.2 (left) above.

For a chromagram, the values are added up by chroma. A chroma can be defined as a pitch class in the chromatic scale classed by octave and enharmonic equivalence. This means that all tones that are less than a quarter tone above or below a tone belong to the same chroma, just like all notes that are within the same range of a tone within the same pitch class. For instance, with a' tuned at 440 Hz, the A-chroma would comprize all frequencies between 427.47 Hz and 452.89 Hz, but also between 213.74 Hz and 226.45 Hz, between 854.95 Hz and 905.79 Hz and so on in both directions because we consider the entire pitch class of A. Chromagrams are useful because they capture the most important data about timbre.[32]

Contrary to most instruments, tubas have an extraordinary high amount of overtones. Whereas for some instruments the use of a logarithmic scale is recommended in chromagrams, because it highlights lower dynamic levels in the overtones, for tuba chromagrams, a linear scale already give us enough insight into the timbre of this instrument.

In my discussion of the sound qualities of the tuba, I used the recordings of Catelinet and Jacobs provided above.[33] Chromagrams of the two cadenzas played by both performers are supplied in Appendix A. Since in the chromagrams it is impossible to distinguish the solo tuba

[31] A Fast Fourier Transform gives the same result as a normal Fourier Transform, but the used algorithm is faster. It is mostly referred to in the short-hand FFT.
[32] The lost information - the tuning and the octaves of overtones - has little to no influence on our perception of timbre.
[33] See footnote 17 above.

from the accompaniment, I provide chromagrams only for the cadenzas, when the tuba plays solo. All chromagram examples in this chapter are drawn from the first cadenza, at the end of the first movement. These chromagram examples demonstrate the findings that I made by studying the complete cadenzas, provided in Appendix A. In the examples the fundamentals are marked with white boxes. Overtones can be distinguished by looking at the other chroma (above and/or below the white boxes) at the same point in time.

It is very important to notice that the chromagrams are biased for the tuba's lower notes in these recordings. The spectrograms of the Catelinet and Jacobs recording show no frequencies below 75Hz (pitch D) and 50Hz (pitch A,), respectively.[34] This is probably because the microphones used in the recordings were not suitable for picking up these frequencies. The lowest frequencies that were picked up might have been recorded at lower dynamics than they were live. However, the bias in the chromagrams is limited: the dynamics of the chroma of the fundamental are affected - if the player would play a G, , the dynamics of the G-chroma would be lower - but all overtones within the audible spectrum are represented at the same level.

In figure 2.2, the spectrograms show that the recording of a note of pitch C has no frequencies within the expected frequency range of the fundamental (63.5 Hz - 67.3 Hz, this is marked by the white box). Even in the spectrogram with a meter scale (Fig. 2.2 b), that highlights frequencies with lower dynamics, the fundamental is not visible. In the chromagram (Fig. 2.2 c) we can see that the C-chroma (marked by a white box) shows only low dynamics.

[34] In the Jacobs recording, lower frequencies do occur, but only when the bass drum is playing, indicating that a seperate microphone was used for this instrument.

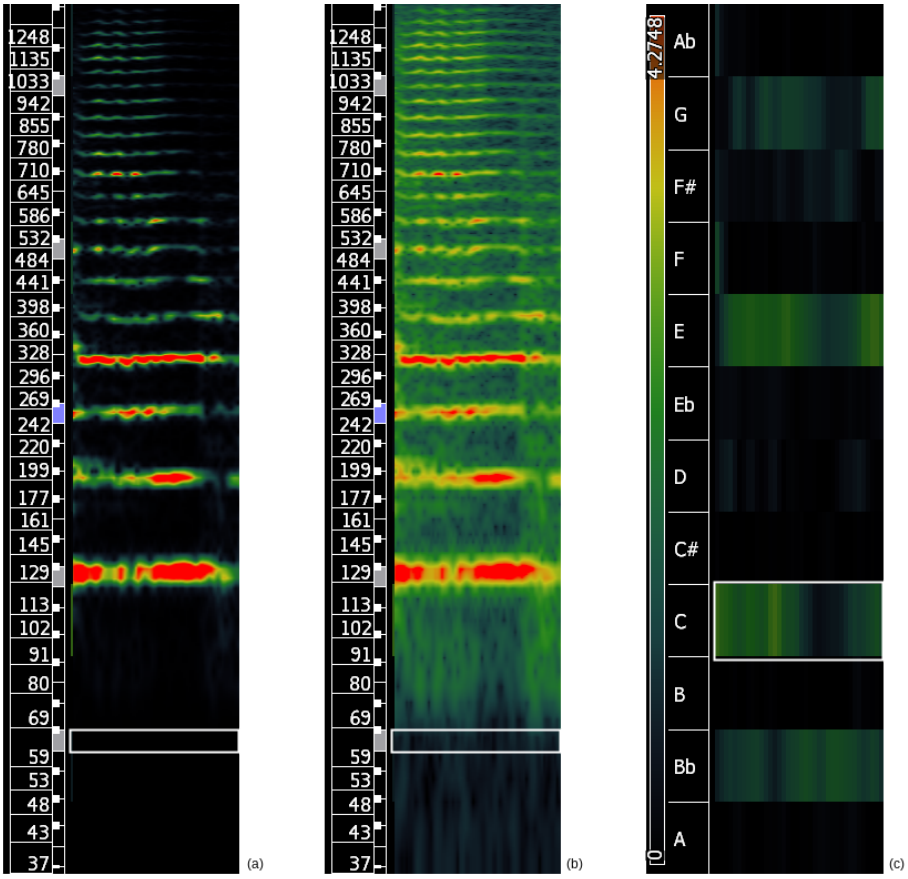


Figure 2.2: a) Spectrogram with linear scale of pitch C played by Philip Catelinet.
b) Spectrogram with meter scale (highlighting lower dynamics more) of the same note.
c) Chromagram of the same note. The white markings indicate the frequency range of the fundamental (pitch C) in the spectrograms (a and b) and the C-chroma in the chromagram (c).

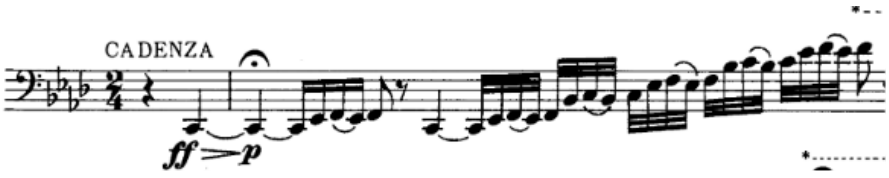
Based on the recordings by Catelinet and Jacobs, we can draw some conclusions about the qualities of the "Barlow" F tubas, which were used by the soloists in these recordings. First, the instruments have a dark and mellow sound - a quality that is also heard in other types of tubas - and something that can be best described as a whisper-like, throaty quality when going towards the lower range of the instrument. The chromagrams show us a strong presence of overtones in the major fifth, major third and minor seventh chroma, the last one corresponding to the occurrence of the whisper-like, throaty quality.[35]

If we look at example 2.3 and the corresponding chromagrams in figures 2.4 - 2.7, we see that for the first note (pitch C, marked by the first white box), the Catelinet and Jacobs chromagram (figure 2.4 and 2.5) show the presence of overtones within the G, E and Bb

[35] Baadsvik used the words "dark and mellow" in his correspondence about the qualities of his Miraphone Eb "Starlight" Tuba. I use the same phrasing, since it captures exactly the effect that I intend to describe.

chroma - that is the major fifth, major third and minor seventh from C. For the second note (pitch Eb, marked by the second white box) we see the presence of overtones in the Bb, G and Dd chroma. This overtone structure is rather consistent, but the overtones do have a relatively softer volume for higher notes.

However, when we look at the Hilgers chromagram (figure 2.6), played on a German F tuba, and the Baadsvik chromagram (figure 2.7), played on German Eb tuba, the overtones are less consistent and the player seems to have a larger impact on the sound quality (for example, the first and the second C in these two modern recordings have a very different sound and show a difference in the chromagram).



Example 2.3: First line of the cadenza in bar 7 in **12**.

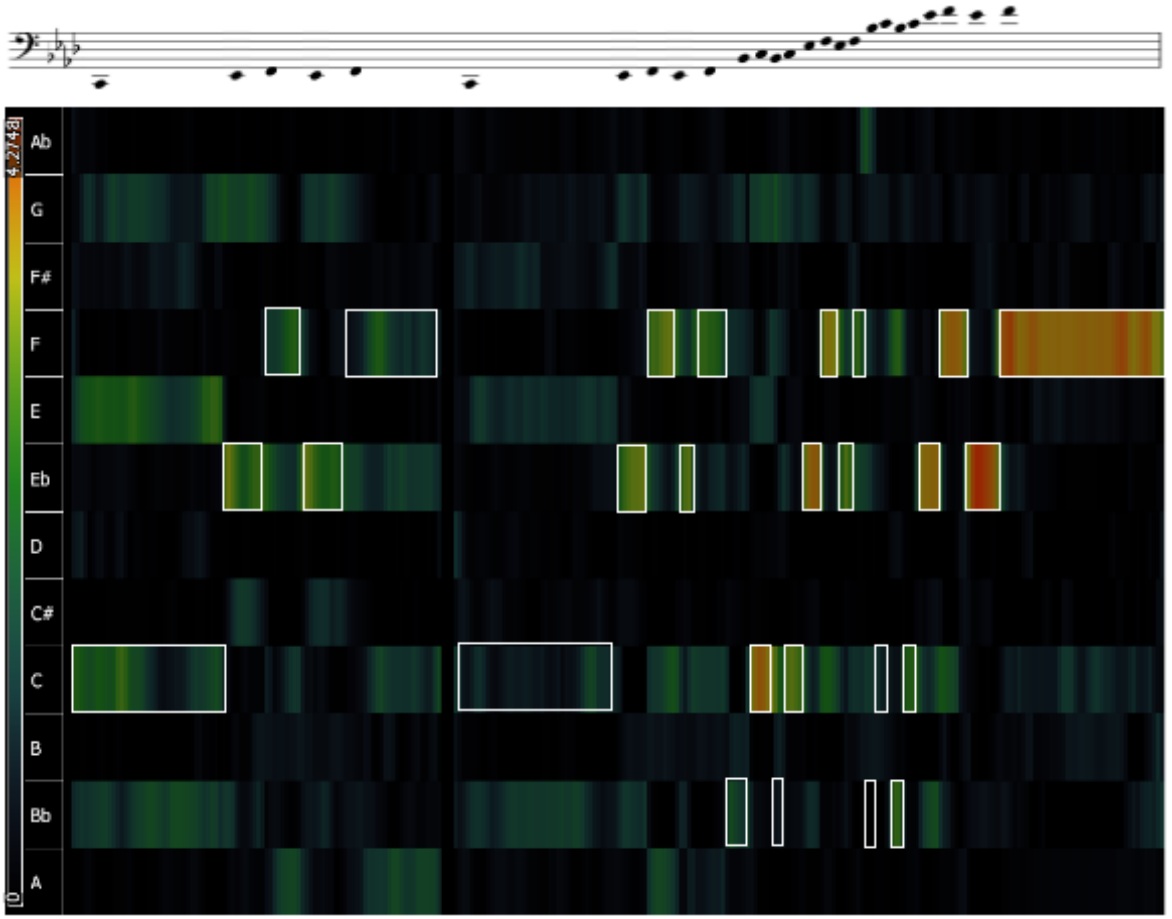


Figure 2.4: Chromagram of the cadenza section from Example 2.3 (recording by Catelinet).

The white boxes indicate the chroma of the fundamental.

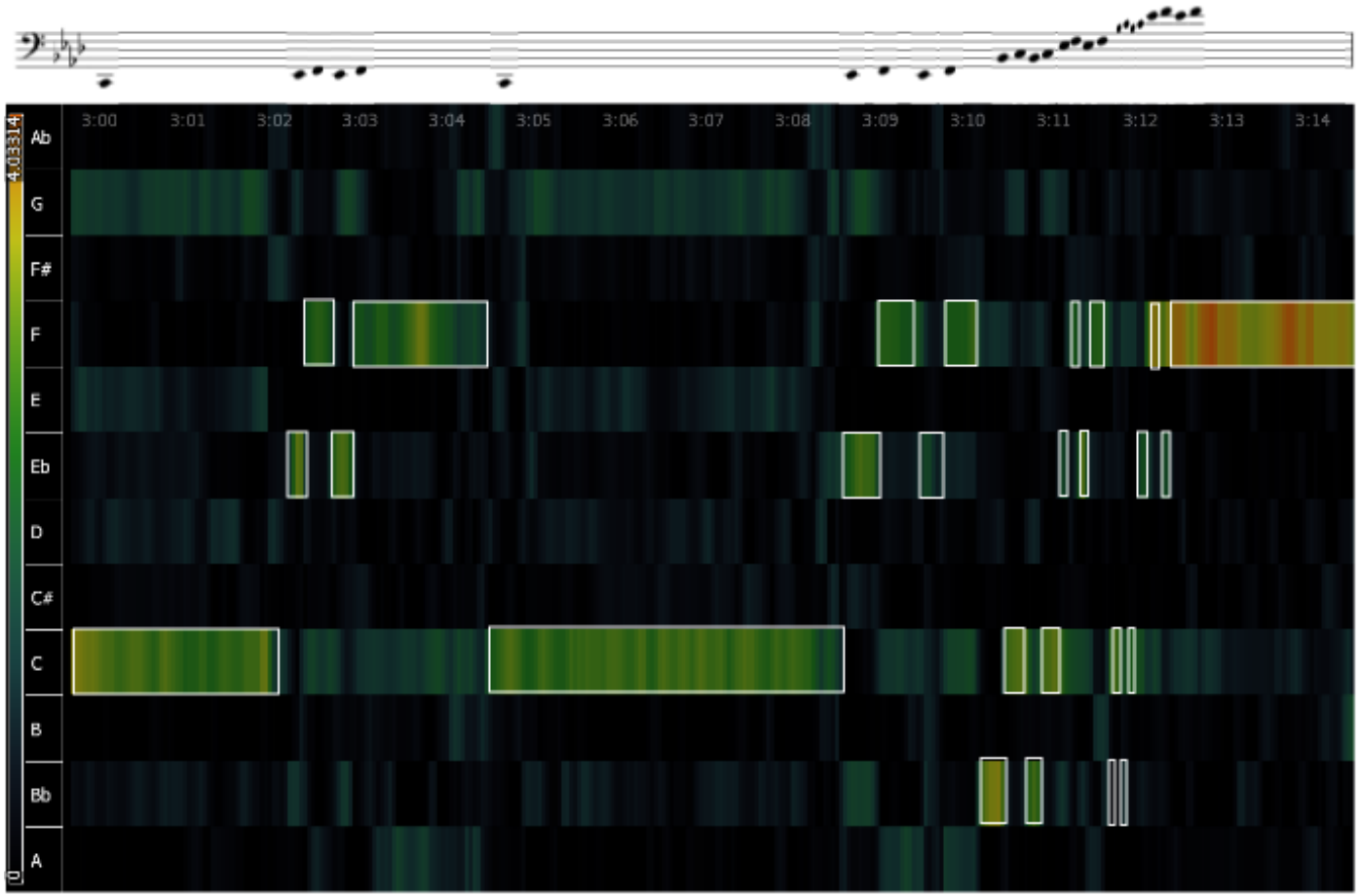


Figure 2.5: Chromagram of the cadenza section from Example 2.3 (recording by Jacobs).

The white boxes indicate the chroma of the fundamental.

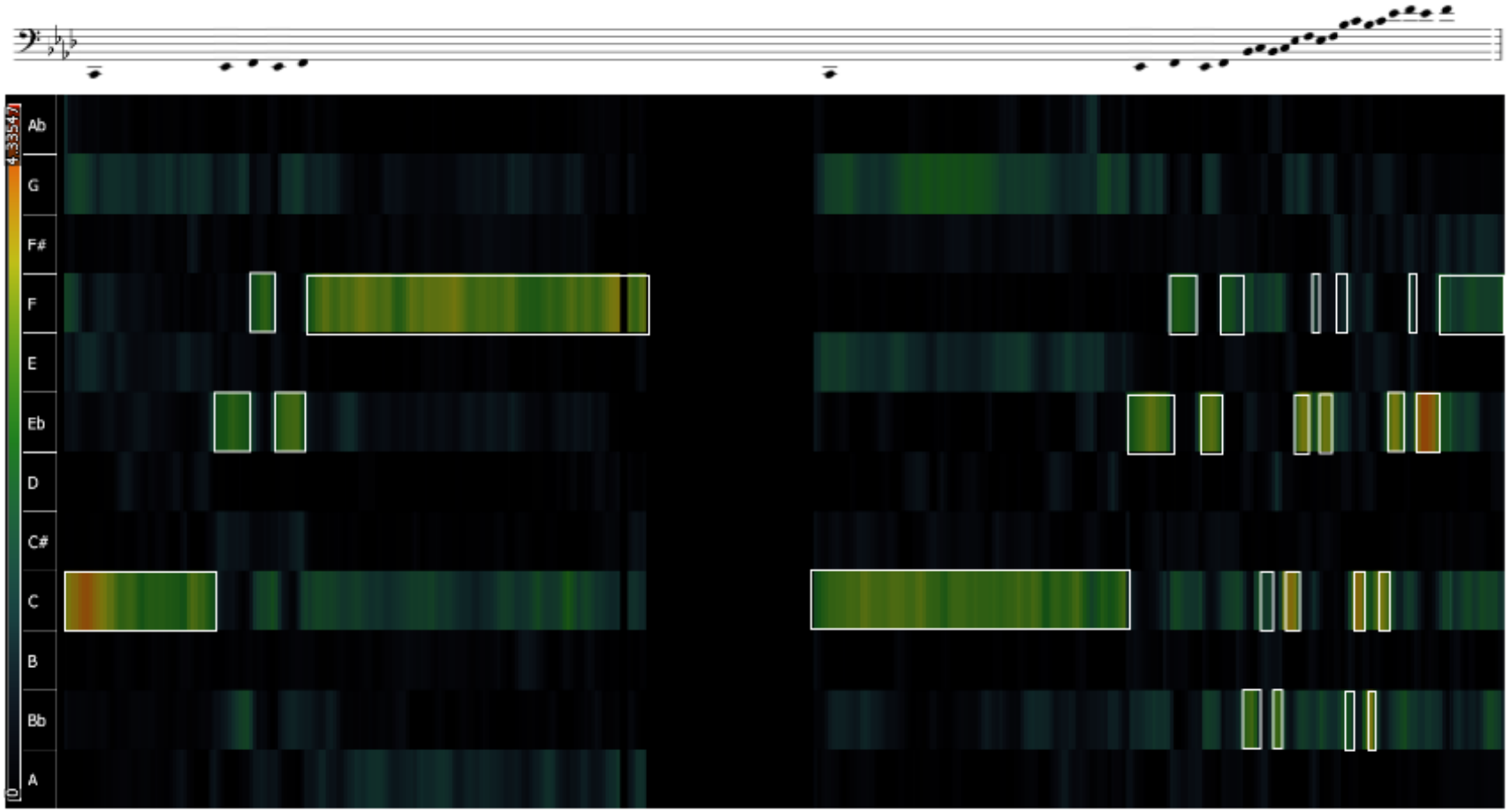


Figure 2.6: Chromagram of the cadenza section from Example 2.3 (recording by Hilgers).

The white boxes indicate the chroma of the fundamental.

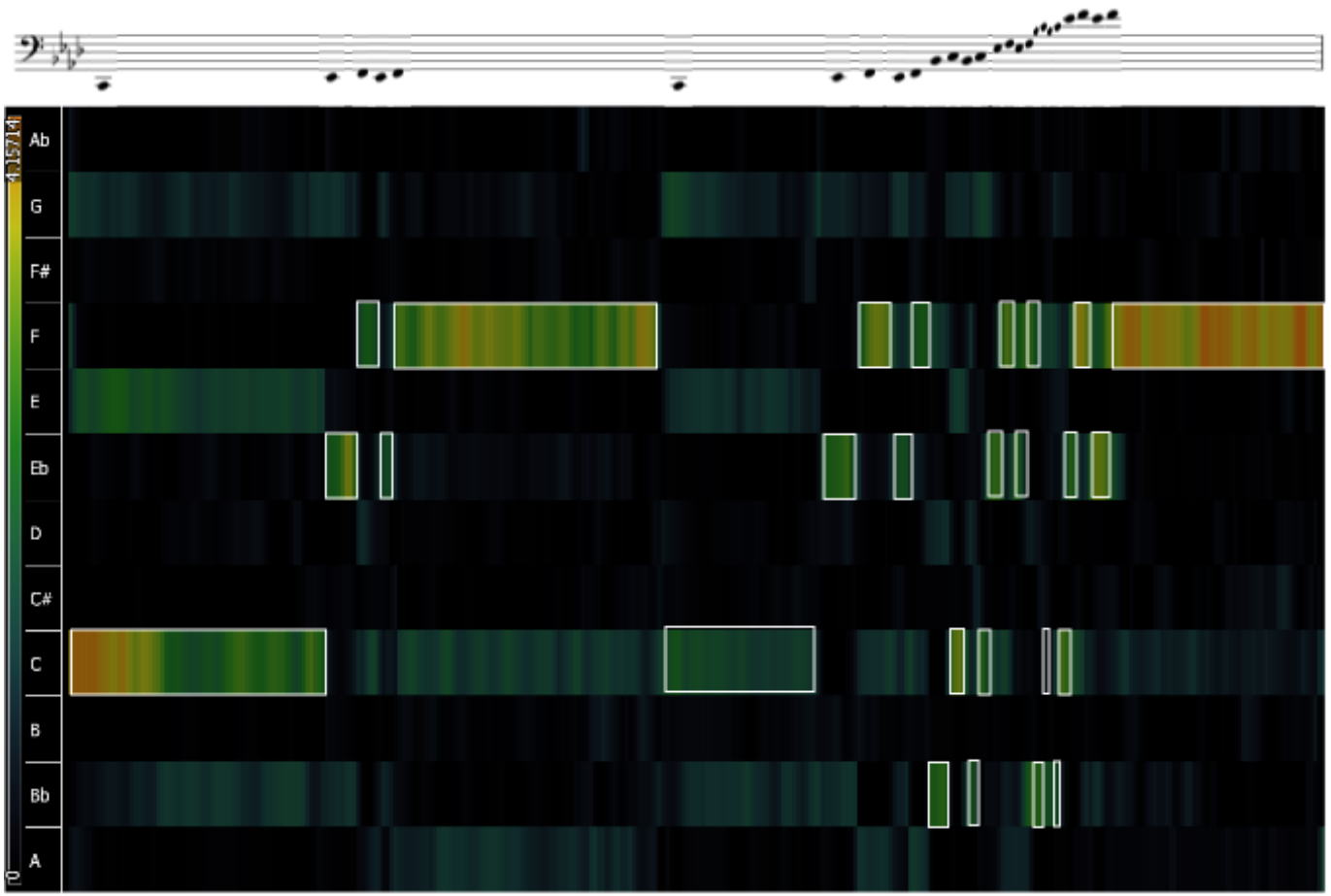


Figure 2.7: Chromagram of the cadenza section from Example 2.3 (recording by Baadsvik).

The white boxes indicate the base chroma.

Here I draw attention to the high presence of overtones in the minor seventh chroma. The first occurrence of this overtone is only at the sixth overtone in the overtone series - at seven times the frequency of the fundamental - and the relatively high dynamics are not completely in line with what one might expect. When listening to the recording, the presence of the minor seventh chroma strongly correlate with the whisper-like, throaty quality of the instrument in the lower range.

Furthermore, we can hear in the recordings and see by the color inconsistencies in the chromagrams (figure 2.4 and 2.5) that the instrument is not very stable in the lower range (C and lower).[36] This is of course very much dependent on the player and how skillfully one can control the instrument in the lower register, but it is obvious that both Catelinet and Jacobs had difficulty keeping these notes stable. This is not surprising, since most British tuba players were euphonium players as well - which lead them to having an embouchure better developed for the higher register - and to facilitate the combination with the euphonium, a tuba with a higher middle range was needed.[37]

In summary, the analysis of the recordings and the chromagrams showed the following results. Both tubas have a dark and mellow sound and a whisper-like throaty quality in the lower range - which correlates to the strong presence of minor seventh overtones. Furthermore, we saw that both performers had trouble in keeping their notes stable in the lower range.

In my experience, the chromagrams are a very effective method for the analysis of timbre and other sound characteristics. They help to get a better insight into the characteristics of an instrument and especially into the overtone structures that influence the timbre. In my study, the chromagrams helped me to identify instabilities in certain passages and they showed structural strong presence of minor seventh overtones in the performances with the British “Barlow” F tuba.

[36] Compared to the same notes in the recordings by Hilgers (figure 2.6) and Baadsvik (figure 2.7), the colors of the Catelinet (figure 2.4) and Jacobs (figure 2.5) chromagrams are not very smooth for lower notes.

[37] Playing a brass instruments asks a lot from the lip muscles (embouchure). The tension on the lips is higher for high notes and lower for low notes and a lot of training is needed for the lip muscles to be able to support the full range of an instrument. Since the euphonium is pitched a fifth higher than the F tuba, the embouchure of a performer trained on the euphonium would be more trained towards a higher register and a tuba that is suited towards this would be more comfortable to play.

Music analysis of the score

The score of Vaughan Williams's Tuba Concerto shows clear indications that it was written with the characteristics of the British F tuba in mind. Throughout the score there are many instances where the composer made an effort to accomodate the tuba as well as he could. The piece is only 15 minutes long, but as a solo performance it is very demanding for the tuba player and especially for the performer's embouchure. The key, F Minor, is a rather comfortable key when playing on an F tuba, since it limits the amount of unpractical valve combinations, and - more particular for the British F tuba - the full range of the instrument is used, ranging from Eb, to f'.[38]

There is some evidence in the orchestration that demonstrates how the composer chose to emphasize the specific timbre of this tuba. Such compositional decisions in orchestration would have been different if this piece was written for another type of tuba. For instance, the doubling of certain solo passages in the bassoon, especially in the lower register, can be interpreted as the composer hinting on the soloists timbre going more towards the bassoon timbre while at the same time offering the performer reinforcement in the low register where the British F Tuba is difficult to control.[39]

Furthermore, the fact that the soloist stays mostly within the higher and middle range of the tuba throughout all three movements, could indicate that the composer favoured the timbre of this range and that he had more trust in the performer's capabilities in this range - relating back to most British tuba players performing on both the tuba and the euphonium and therefore being more at ease in this higher register. It could also be used as a way for the soloist to stand out against the accompaniment, which is easier to notice in this higher register.

The analysis of the separate movements that follows, gives an overview of several key elements in the score that indicate the composer "helping" the performer in his performance of this virtuosic piece and by highlighting the best features of the British "Barlow" F tuba. The score of the concerto can be found in Appendix B.

---

[38] Vaughan Williams changed the cadenza during the rehearsals for the premiere, because the g ♭' and a ♭' that were in the Candenza were not playable at an acceptable quality. In the 2010 edition the original notes are included, marked with the notion "to be omitted if preferred". More information on his this change can be found in Catelinet, "Truth", 30-33.

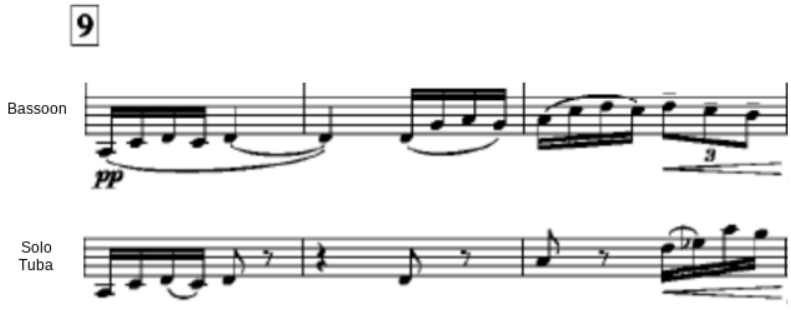
[39] The composer also frequently uses the basses, but this is more logical since they are the only instrument in the orchestra (used in this piece) that is able to reach notes below the A,

Movement 1

From the start of the first movement, Vaughan Williams allows the soloist to sound virtuosic without actually playing that fast, by using only a simple accompaniment. When the tuba ends this musical line by going down towards the G♭, (bar 11) the cellos and basses double the tuba and unlike the soloist, they sustain the F, that follows. Not only does this allow the soloist to breath before the next entrance, but more importantly this supports the soloist in the less stable lower range.[40]

Vaughan Williams uses a lot of contrast to make the tuba sound more like a classical solo instrument. The *pianos* in the solo part are preceded and followed by *fortissimo* and *forte* passages in the orchestra, hiding the fact that a tuba could never play as soft as for instance a violin.

The solo part has many short rests allowing the soloist to breathe. This is needed to prevent the player from having to break in the middle of a phrase. A nice example can be found in the first three bars of **9**, where breathing gaps in the soloist's melodic line are filled by the bassoon (Ex. 2.8). Even though most earlier occurrences of breathing opportunities could also just be seen as part of the musical line, here we see a very clear instance of the composer helping the soloist by creating a dialogue with another instrument during silences.



Example 2.8: Bassoon and solo tuba part in the first three bars of **9**

When the soloist reaches the candenza, the slow tempi do not force the player into unplayable virtuosities and the left out (or ad libitum) g♭' and a♭' give the player the opportunity to stay within the comfortable range of the instrument. The large leap in bars 5, 6

[40] This structure - where the soloist is doubled by the accompaniment - occurs every time the soloist plays sustained notes in this lower register. Examples can be found four bars before **2**, bar 4 and 6 in **6** and the last bar before **7**.

and 7 of the 'a tempo' are somewhat more risky, but not impossible to play. At the final notes of the movement - the F¸ and E♭¸ are hard to keep stable - the orchestra joins in again supporting the tuba sound at the end of the movement.

Movement 2 - Romanza

Although the musical lines in the "Romanza" are a bit longer than in the first and third movement, the *piano* and *pianissimo* still allow the soloist to play them without too much inconvenience. When the soloist has to play a longer line in *forte* and *fortissimo* (between **6** and **7**), the composer adds a comma (bar 5 in **6**).[41] There are no highly virtuosic passages and the soloist only reaches into the lower range twice. At these points, the bassoon and the basses double the solo part, similar to what happened in the first movement.[42]

Movement 3 - Finale - Rondo alla Tedesca

Though the music seems to invite the soloist to go to the virtuosic limit in the "Finale", the Rondo alla tedesca in the title indicates that the movement should be played like a German waltz.[43]

Though this movement is in a completely different tempo and style, the composer uses similar techniques as in the first movement. The soloist presents a theme that is repeated by the orchestra. However, contrary to the first movement, the soloist is not silent while the orchestra repeats the theme, but starts to elaborate the theme further while the orchestra is still playing. This gives the whole a more virtuosic feeling, but also asks a lot more from the soloist now than previously.

The cadenza has no tempo marking, but is usually played slower than the orchestra passage before. Though more virtuosic than the first cadenza, it is limited in comparison to the whole "Finale". The real lower register is reserved for the last four bars. Here the notes at pitch G♭¸ and F¸ are doubled (albeit an octave higher) by the trombones, while the strings and woodwinds play a fast downwards line towards the final note of the concerto.

---

[41] This is probably not the only spot in the passage where a tuba player might breath, but it shows the intended way of phrasing.

[42] The two instances of the soloist going into the lower range at **2** and **7** are marked in the part, because playing them an octave higher allows the movement to be performed on cello or bassoon. Both instances display the same musical line. At the second instance, the bassoon is omitted from the accompaniment and only the basses double the solo part.

[43] Catelinet mentions that the composer suggested a steady tempo in this movement. Catelinet, "Truth", 31-32.

Conclusion

In summary, my study has shown that the British “Barlow” F tubas have a characteristic sound, mainly in the lower register, and Vaughan Williams was aware of how to highlight this feature in his concerto for the tuba, the first solo concerto and the most performed until today. The throaty, whisper-like quality that is present in this lower range, seems to correlate with the strong presence of overtones in the minor-seventh chroma. Although a larger study, with more players and more instruments, is needed to verify this, this could very well be a key characteristic of the British F tuba. Furthermore, we have seen that both Catelinet and Jacobs had trouble in keeping notes stable in the lower range of the instrument.

The music analysis of the score has shown that the composer knew of the challenges that a tuba player faces when playing such a virtuosic concerto. Though it is hard to deduct a composer’s views on timbre from a score, the frequent use of the bassoon to double the solo part throughout the concerto - rather than a trombone or a French horn - can be interpreted as an indication that Vaughan Williams thought of the timbre of these instruments to be alike in the lower register.

The results of this analysis should not be seen as a discouragement to perform this concerto on contemporary tubas. However, it should encourage critical thinking about how this piece should be performed on a contemporary instrument with respect to the composer’s intentions.

The use of chromagrams as a method for analysing the timbre and other sound characteristics of an instrument offers another perspective and supports the analysis of the score. The strong presence of overtones in the minor seventh chroma, could not have been detected solely through an aural analysis. Furthermore, the chromagrams offer a visual confirmation of what can be heard in the recording.

I would recommend chromagrams especially in organological studies and would be very interested in a larger study to analyse and compare the vast amount of historical and contemporary tubas in existence. This could offer a new scholarly insight into the musical decision of choosing the perfect instrument for a piece that is faced so often by many tuba players across the world.

Bibliography

Alperson, Philip. “The Instrumentality of Music.” *The Journal of Aesthetics and Art Criticism* 66, no. 1 (January 1, 2008): 37–51.

Bevan, Clifford. “‘A Magnificent Instrument.’” Edited by Clifford Bevan and Craig Kridel. *ITEA Journal*, 2012.

———. *The Tuba Family*. London: Faber and Faber, 1978.

———. *The Tuba Family*. 2nd ed. rev., enl. and updated. Winchester, UK: Piccolo Press, 2000.

———. “Think Me Up a Tuba.” *ITEA Journal*, 2001.

———. “Vaughan Williams’s Tuba Concerto: Composition and First Performance.” *ITEA Journal* 35 (Winter 2008): 62–63.

Bijsterveld, Karin, and Peter Frank Peters. “Composing Claims on Musical Instrument Development: A Science and Technology Studies’ Contribution.” *Interdisciplinary Science Reviews* 35, no. 2 (June 1, 2010): 106–21.

Catelinet, Philip B. “The Truth About the Vaughan Williams Tuba Concerto.” *ITEA Journal* 14, no. 2 (November 1986): 30–33.

Cook, Nicholas. “Beyond the Notes.” *Nature* 453 (June 25, 2008): 1186–87.

———. “Methods for Analysing Recordings.” In *The Cambridge Companion to Recorded Music*, edited by Nicholas Cook, 221–45. Cambridge Companions to Music. Cambridge, UK: Cambridge University Press, 2009.

Cook, Nicholas, and Daniel Leech-Wilkinson. “A Musicologist’s Guide to Sonic Visualiser.” CHARM, 2009. http://www.charm.rhul.ac.uk/analysing/p9_1.html.

Dawe, Kevin. “People, Objects, Meaning: Recent Work on the Study and Collection of Musical Instruments.” *The Galpin Society Journal* 54 (2001): 219–32.

Frederiksen, Brian. *Arnold Jacobs: Song and Wind*. Edited by John Taylor. 6th pr. Gurnee, IL: WindSong Press, 2006.

Frogley, Alain, and Aidan J. Thomson, eds. *The Cambridge Companion to Vaughan Williams*. Cambridge Companions to Music. Cambridge, UK: Cambridge University Press., 2013.

Herbert, Trevor, and John Wallace. *The Cambridge Companion to Brass Instruments*. Cambridge: Cambridge University Press, 1997.

Kennedy, Michael. *The Works of Ralph Vaughan Williams*. New ed. London; New York: Oxford University Press, 1980.

Müller, Meinard. *Fundamentals of Music Processing: Audio, Analysis, Algorithms, Applications*. Springer, 2015.

Myers, Arnold. “Acoustical History of the Tuba.” *The Journal of the Acoustical Society of America* 125, no. 4 (April 1, 2009): 2598–2598.

———. “The Typology and Timbre of the Tuba,” In *Proceedings of the 41st Academic Conference and 33rd Symposium on Musical Instrument Making From the serpent to the tuba: Development and use of low lip-vibrated wind instruments with holes and valves*. Blankenburg (Harz), Germany: Kloster Michaelstein, forthcoming.

Myers, Arnold, Robert W. Pyle Jr, Joël Gilbert, D. Murray Campbell, John P. Chick, and Shona Logie. “Effects of Nonlinear Sound Propagation on the Characteristic Timbres

of Brass Instruments.” *The Journal of the Acoustical Society of America* 131, no. 1 (January 2012): 678–88.

Vaughan Williams, Ralph. “Concerto for Bass Tuba and Orchestra.” Oxford, UK: Oxford University Press, 1978.

———. “Concerto for Bass Tuba and Orchestra.” Oxford, UK: Oxford University Press, 2012.

———. *Concerto for Tuba: Reduction for Tuba and Piano*. Oxford, UK: Oxford University Press, 1955.

Willetts, P. J. “The Ralph Vaughan Williams Collection.” *The British Museum Quarterly* 24, no. 1/2 (1961): 3–11.

Winston Morris, R. *Guide to the Tuba Repertoire, Second Edition: The New Tuba Source Book*. Bloomington: Indiana University Press, 2006.

Discography

Baadsvik, Øystein, tuba player. Ralph Vaughan Williams, composer. “Concerto for Bass Tuba and Orchestra.” Singapore Symphony Orchestra. Anne Manson, conductor. Google Play Music. Track 1-3 on Øystein Baadsvik. *20th Century Tuba Concertos*. BIS 1515, 2008.

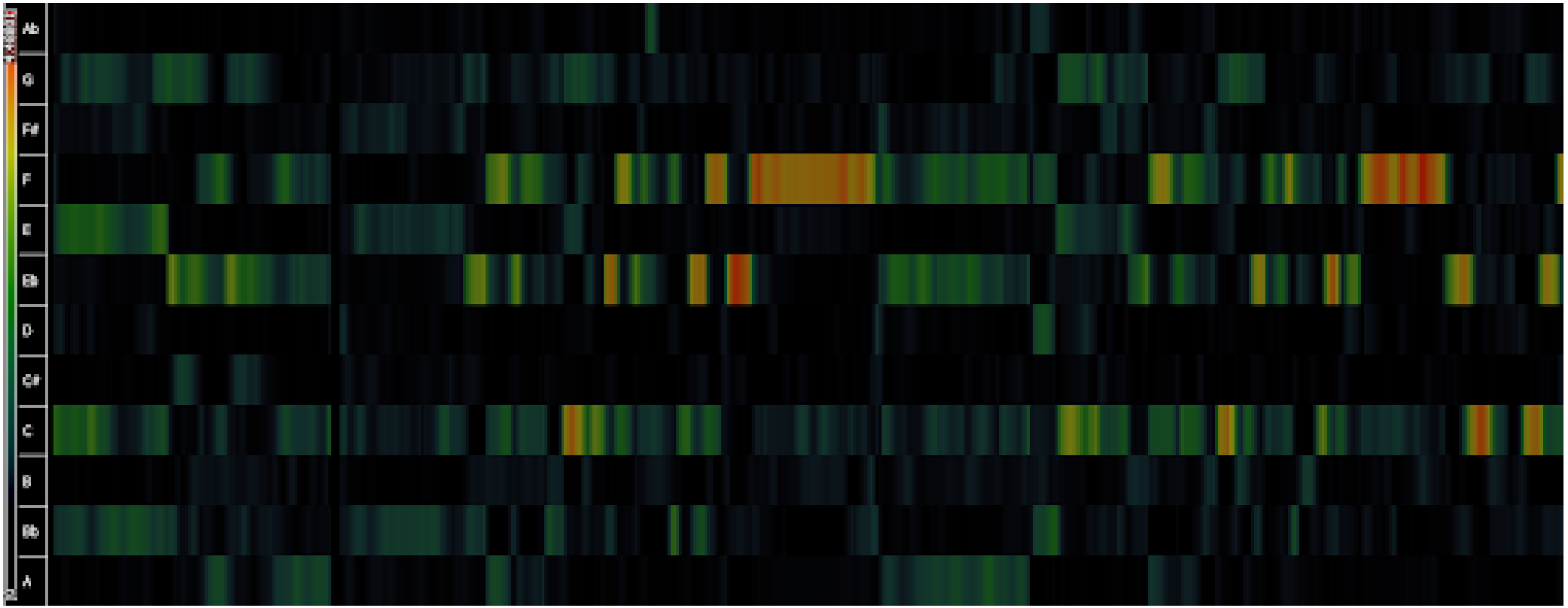
Catelinet, Philip B. tuba player. Ralph Vaughan Williams, composer. “Concerto for Bass Tuba and Orchestra.” London Symphony Orchestra. Sir John Barbirolli, conductor. Recorded June 14, 1954. Google Play Music. Track 4-6 on London Symphony Orchestra. *Vaughan Williams: Oboe Concerto*. 2000.
Available via Youtube. Accessed January 15, 2019.
https://www.youtube.com/watch?v=i9Rkaz1v5GI.

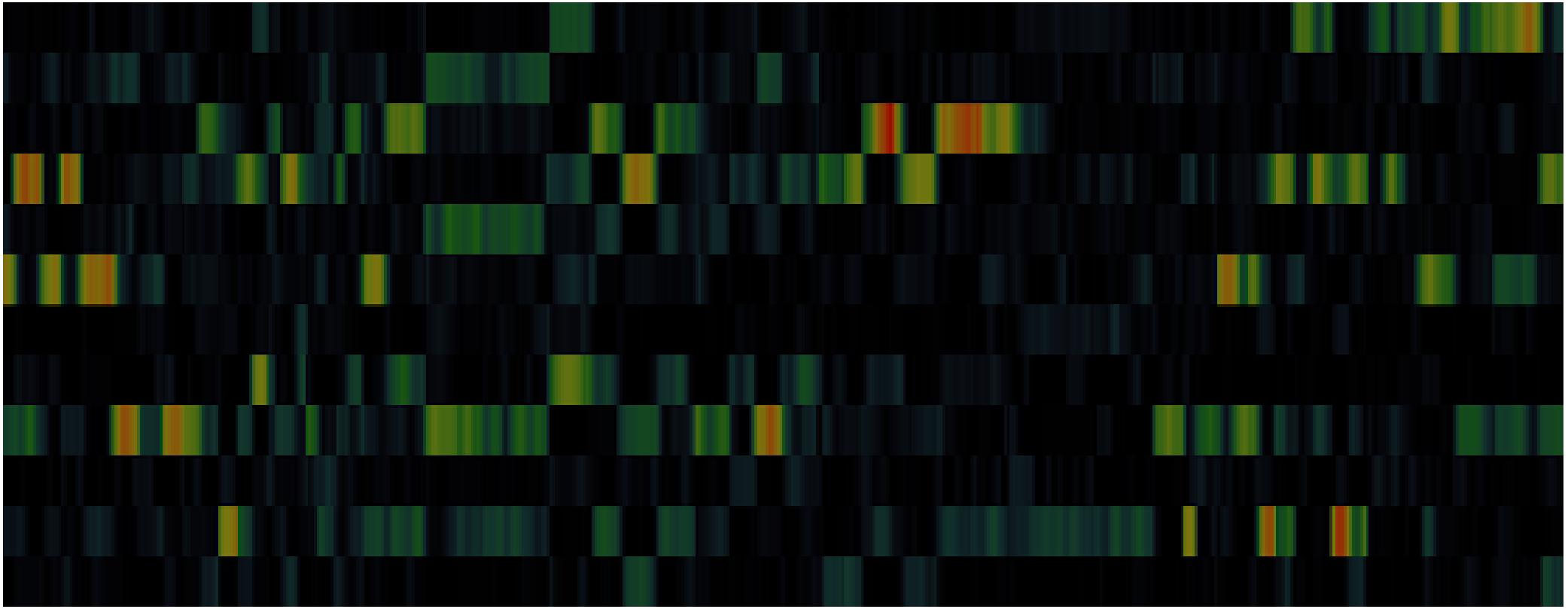
Hilgers, Walter, tuba player. Ralph Vaughan Williams, composer. “Concerto for Bass Tuba and Orchestra.” Brandenburgisches Staatsorchester Frankfurt. Google Play Music. Track 2-4 on Brandenburgisches Staatsorchester Frankfurt. *Ralph Vaughan Williams : Sea Song, Concerto for Tuba, Symphony No. 5*. Genuin, 2006.

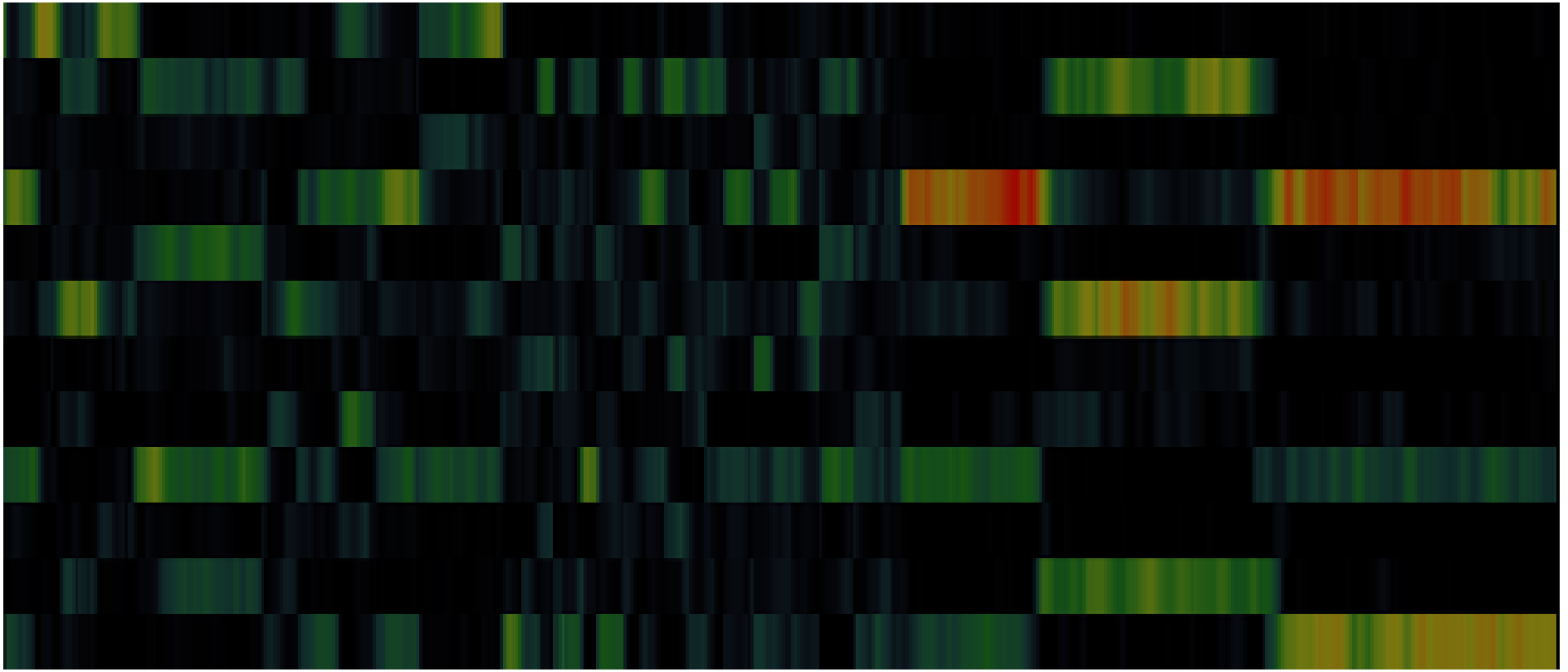
Jacobs, Arnold, tuba player. Ralph Vaughan Williams, composer. “Concerto for Bass Tuba and Orchestra”, Chicago Symphony Orchestra. Henry Mazer, conductor. Recorded October 26 & 28, 1978. Track D2 on Chicago Symphony Orchestra. *From The Archives Vol.2 : Soloists of the Orchestra*. CSO 87/2. 1987.
Available via Youtube. Accessed January 15, 2019.
https://www.youtube.com/watch?v=WLg42fTu_2o.

Appendix A: Chromagrams

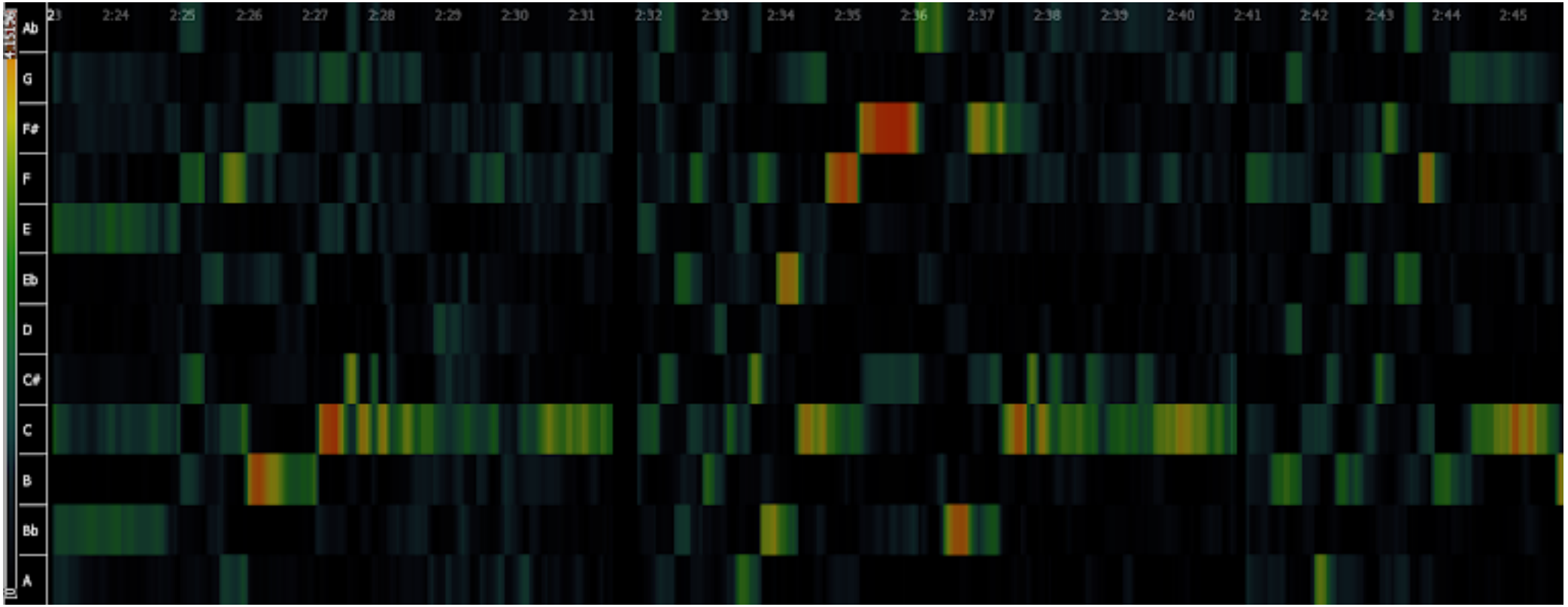
Catelinet, Cadenza from Movement 1

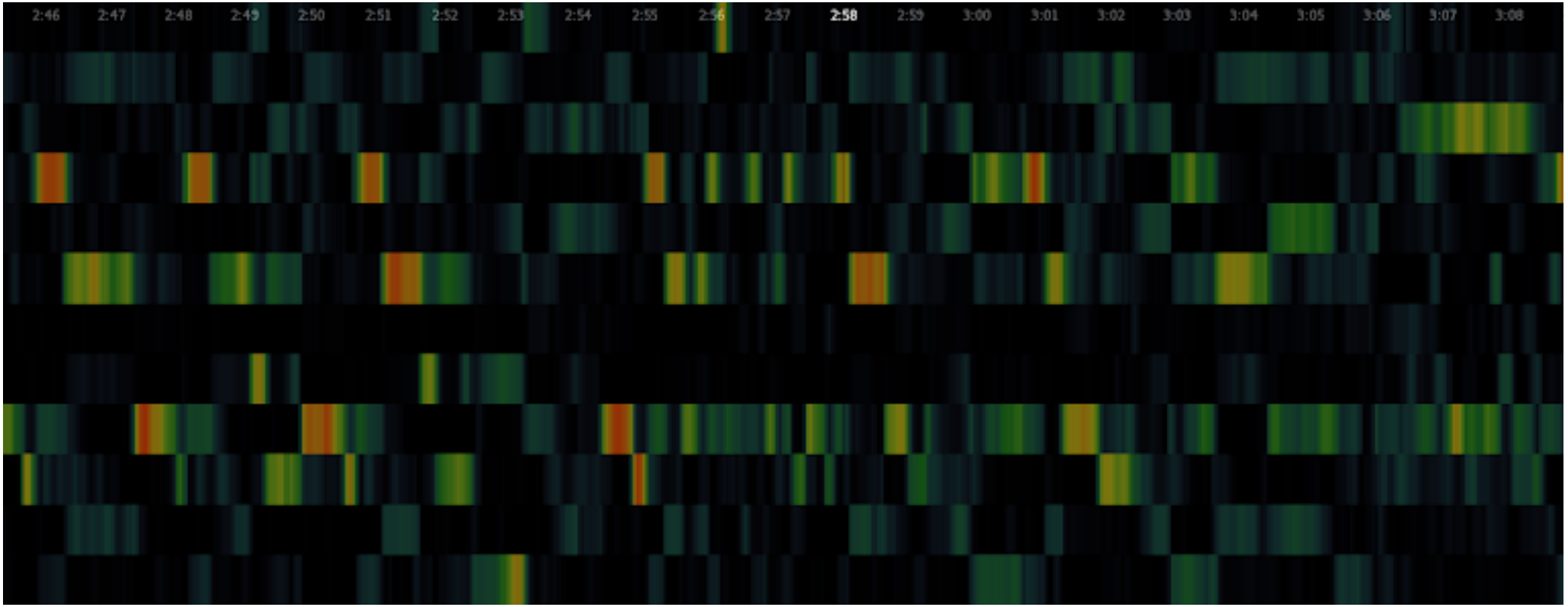


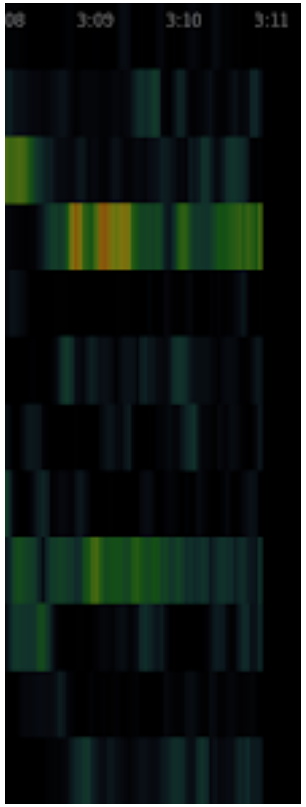




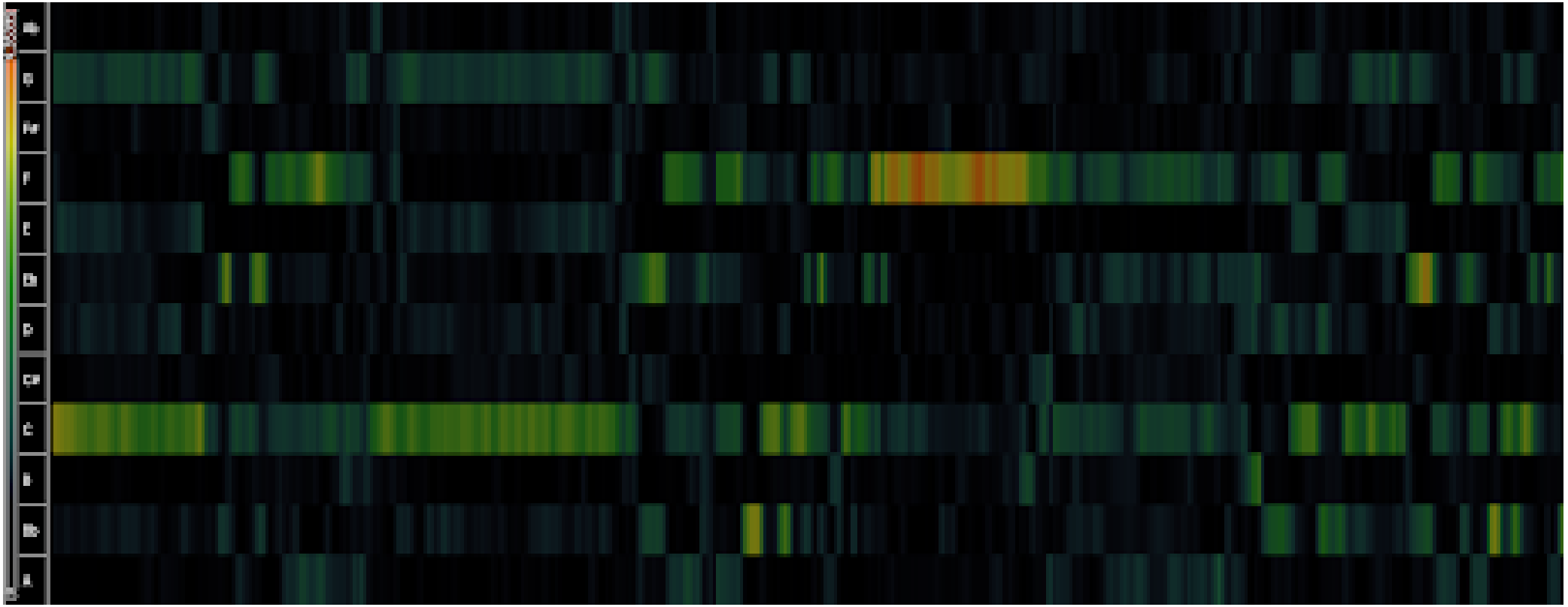
Catelinet - Cadenza from Movement 3

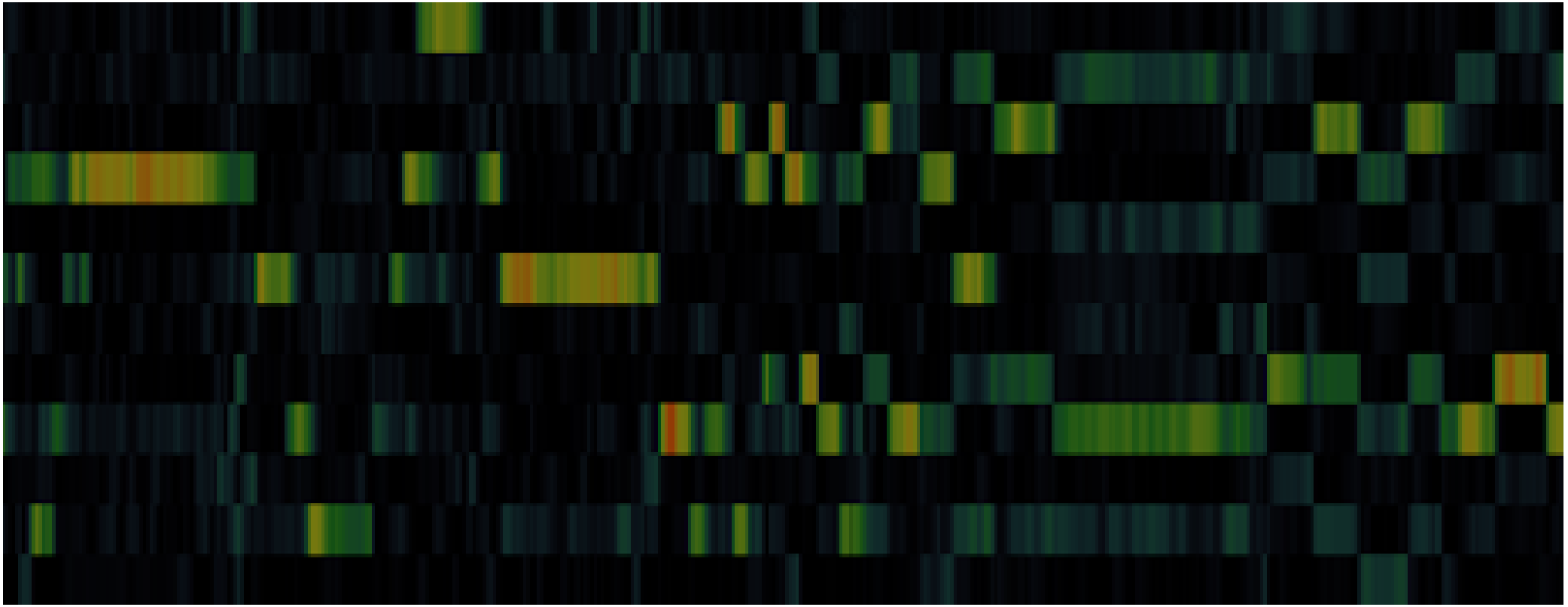


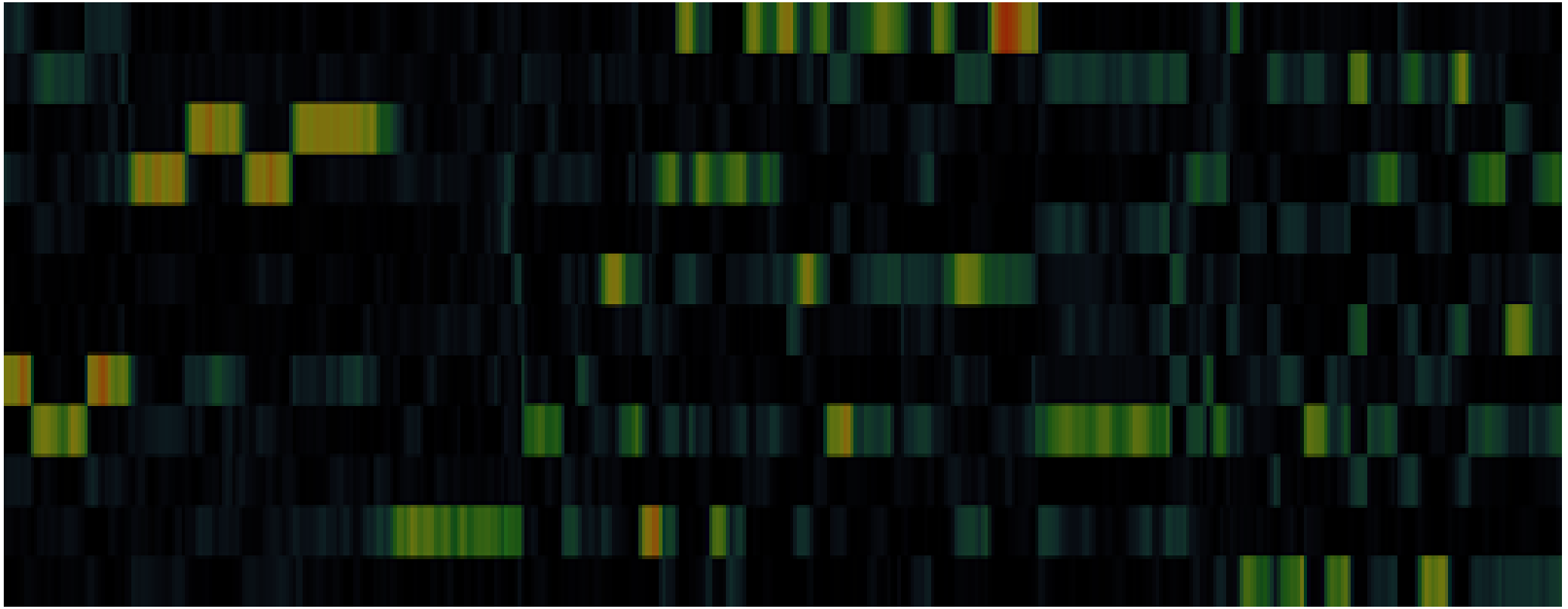

2:46
2:47
2:48
2:49
2:50
2:51
2:52
2:53
2:54
2:55
2:56
2:57
2:58
2:59
3:00
3:01
3:02
3:03
3:04
3:05
3:06
3:07
3:08

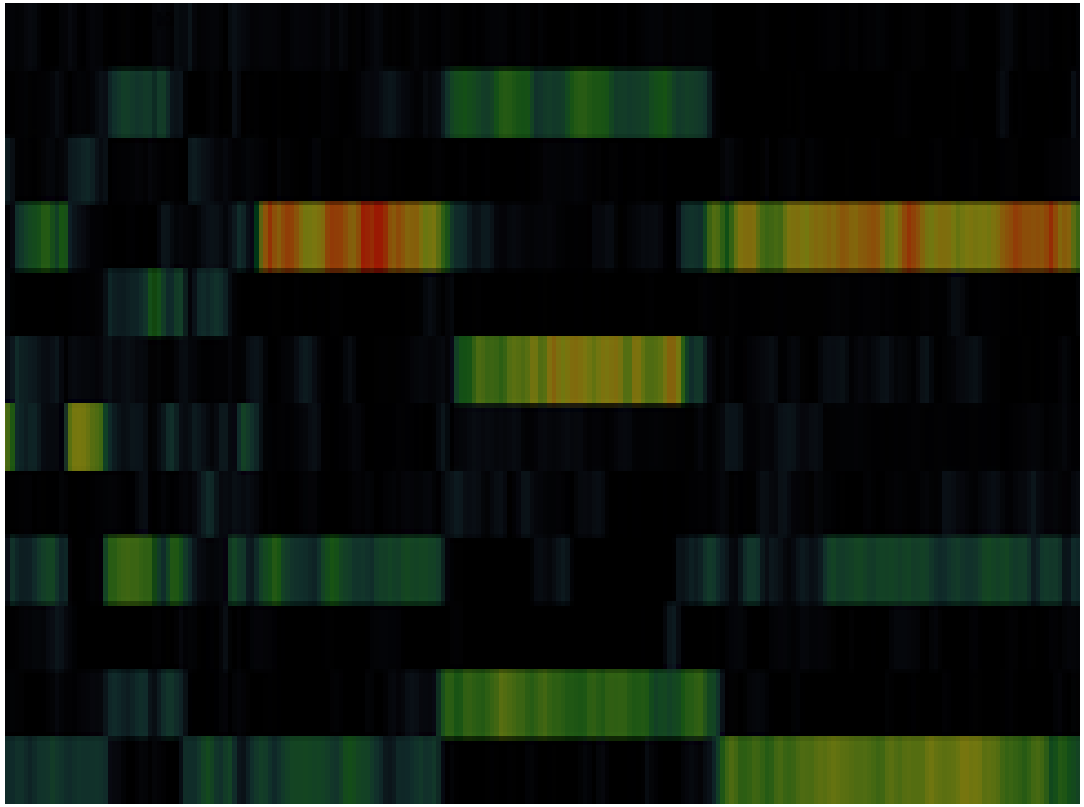

3:09
3:10
3:11

Jacobs - Cadenza from Movement 1

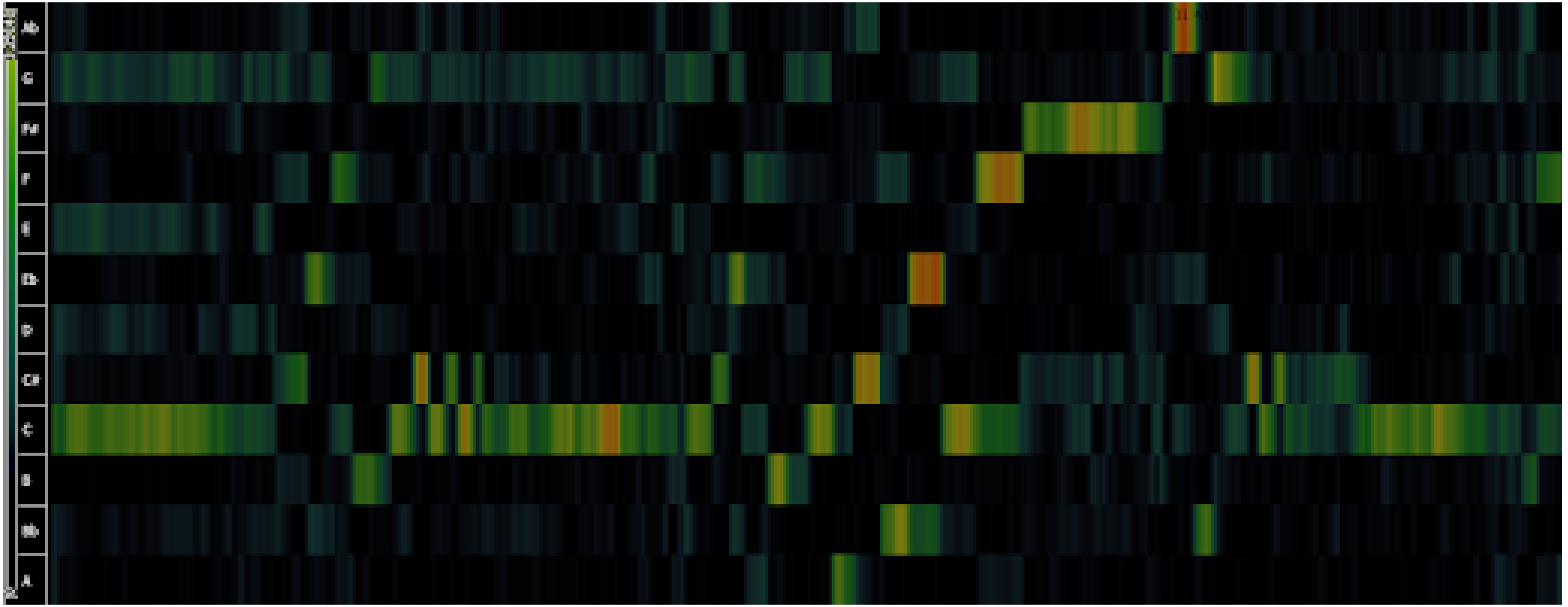


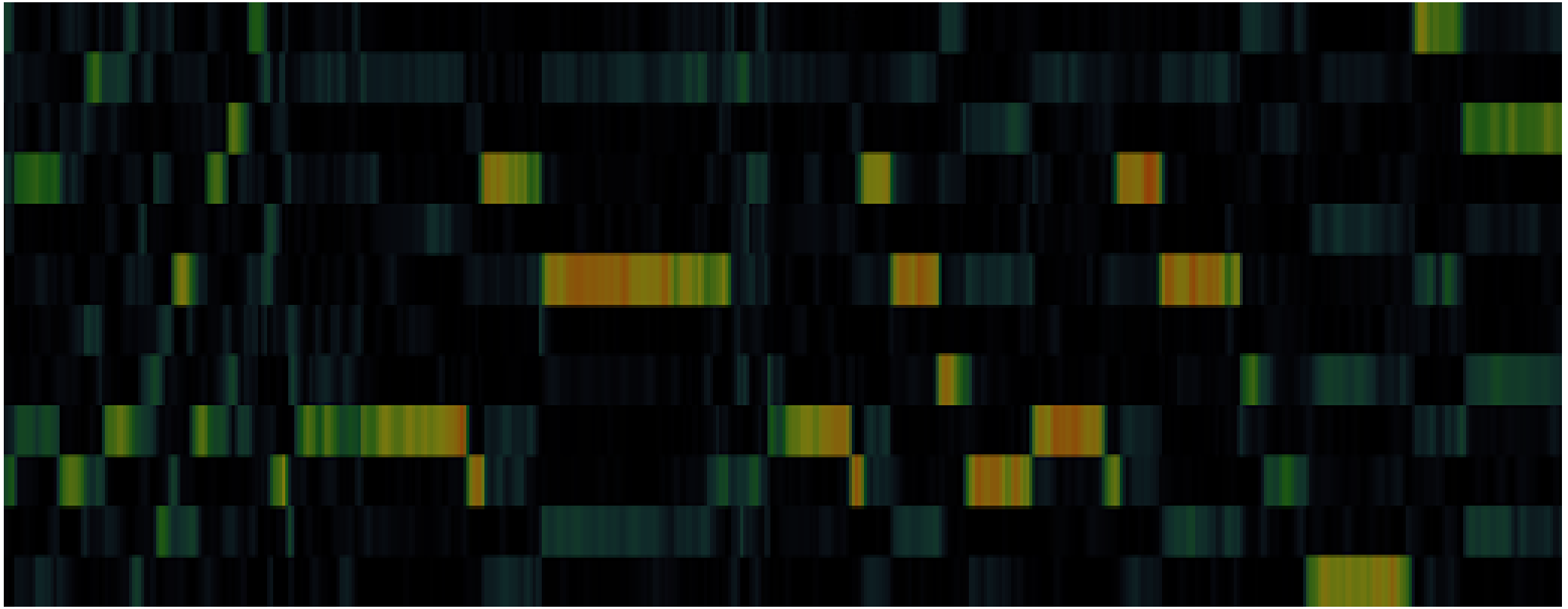


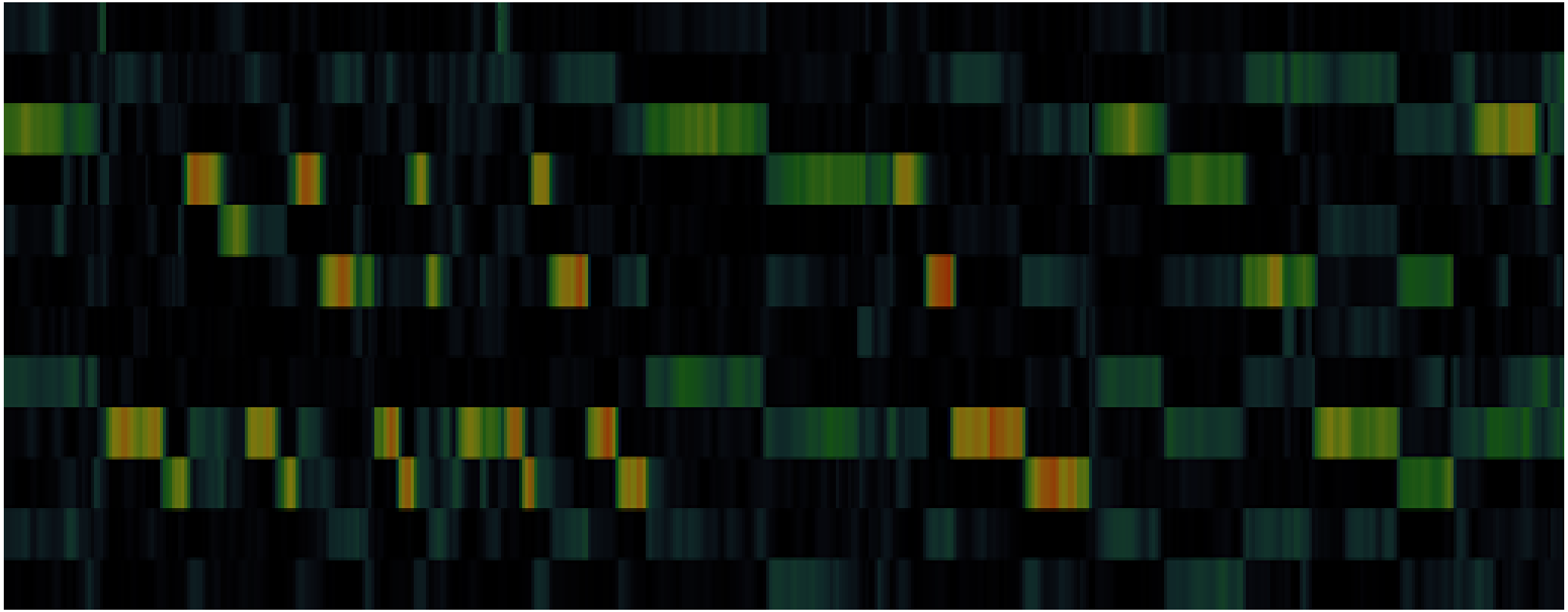


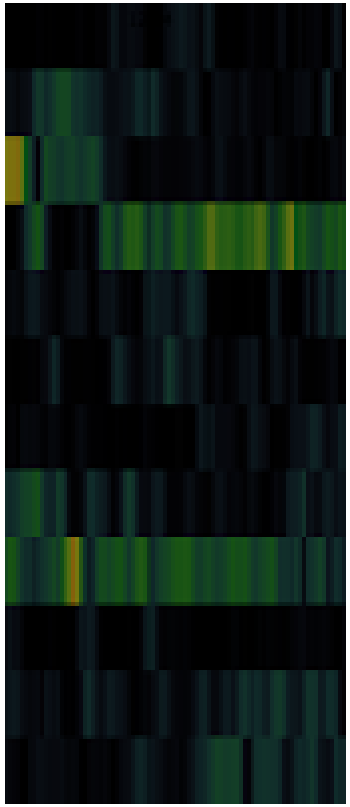


Jacobs - Cadenza from Movement 3









Appendix B: Score

This appendix contains an unedited score of Ralph Vaughan Williams's Concerto for Bass Tuba and Orchestra.

Below an overview of the movements and cadenzas in this score is provided.

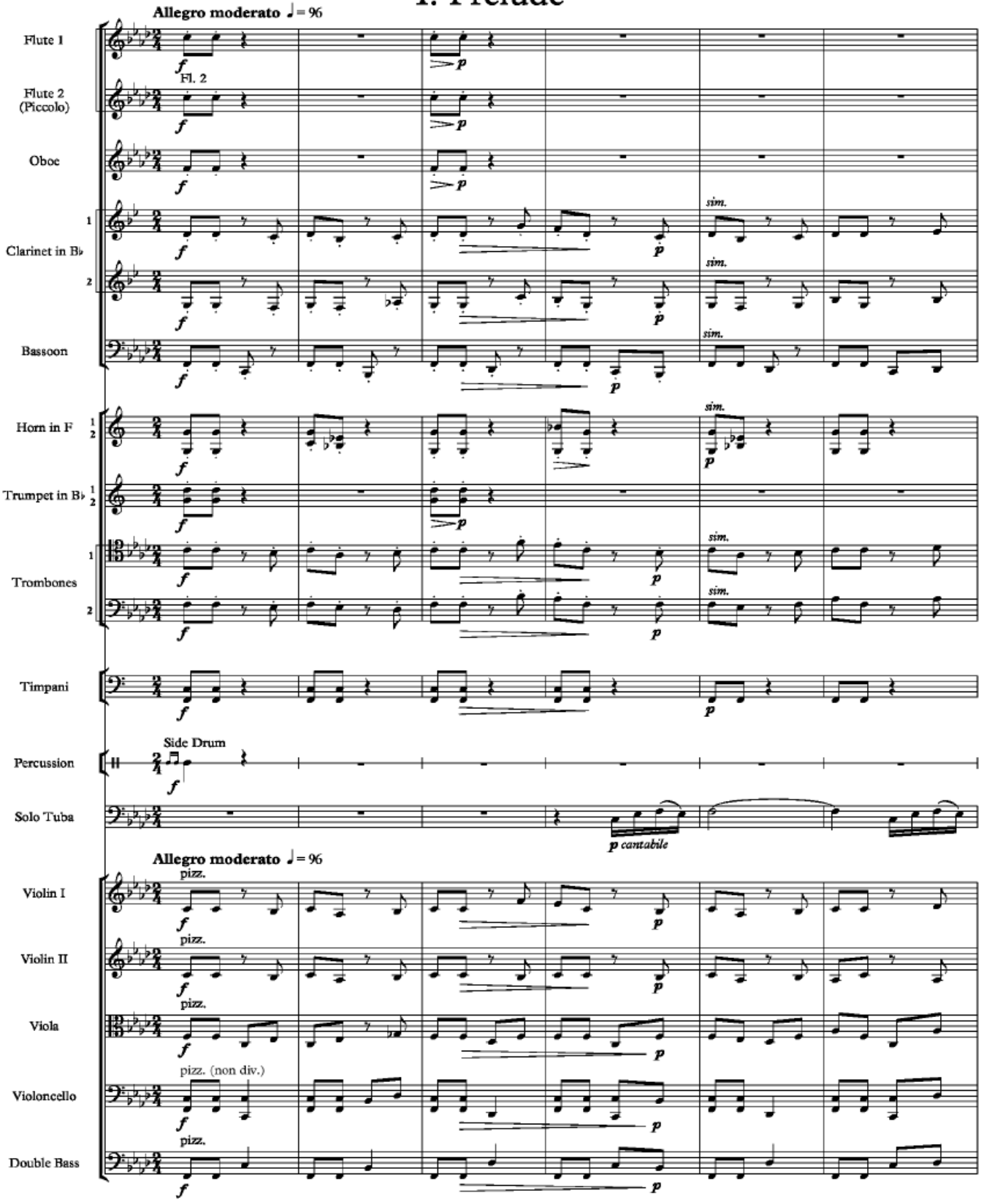
Ralph Vaughan Williams, *Concerto for Bass Tuba and Orchestra* (Oxford, UK: Oxford University Press, 2012).

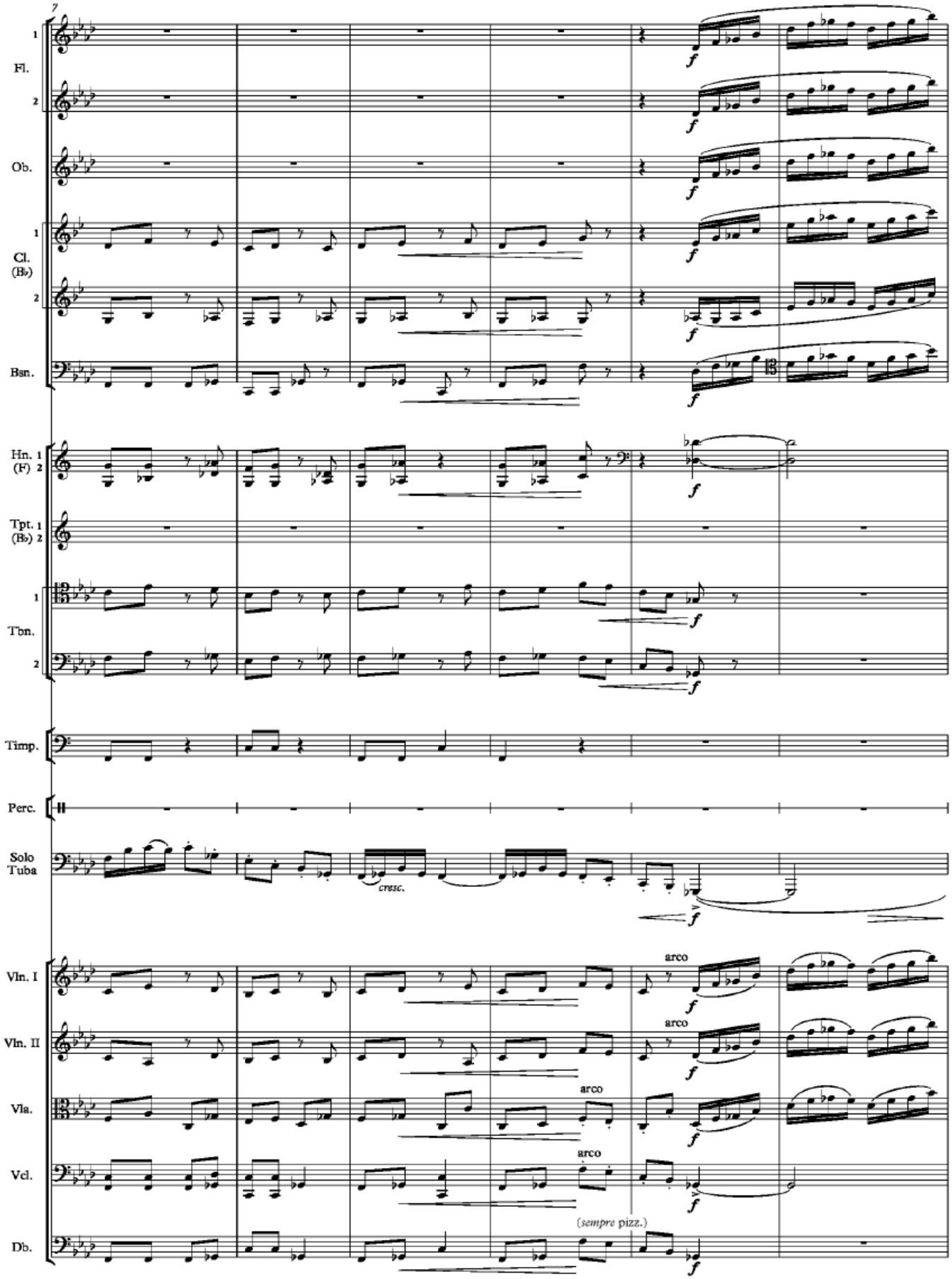
Dedicated to the London Symphony Orchestra

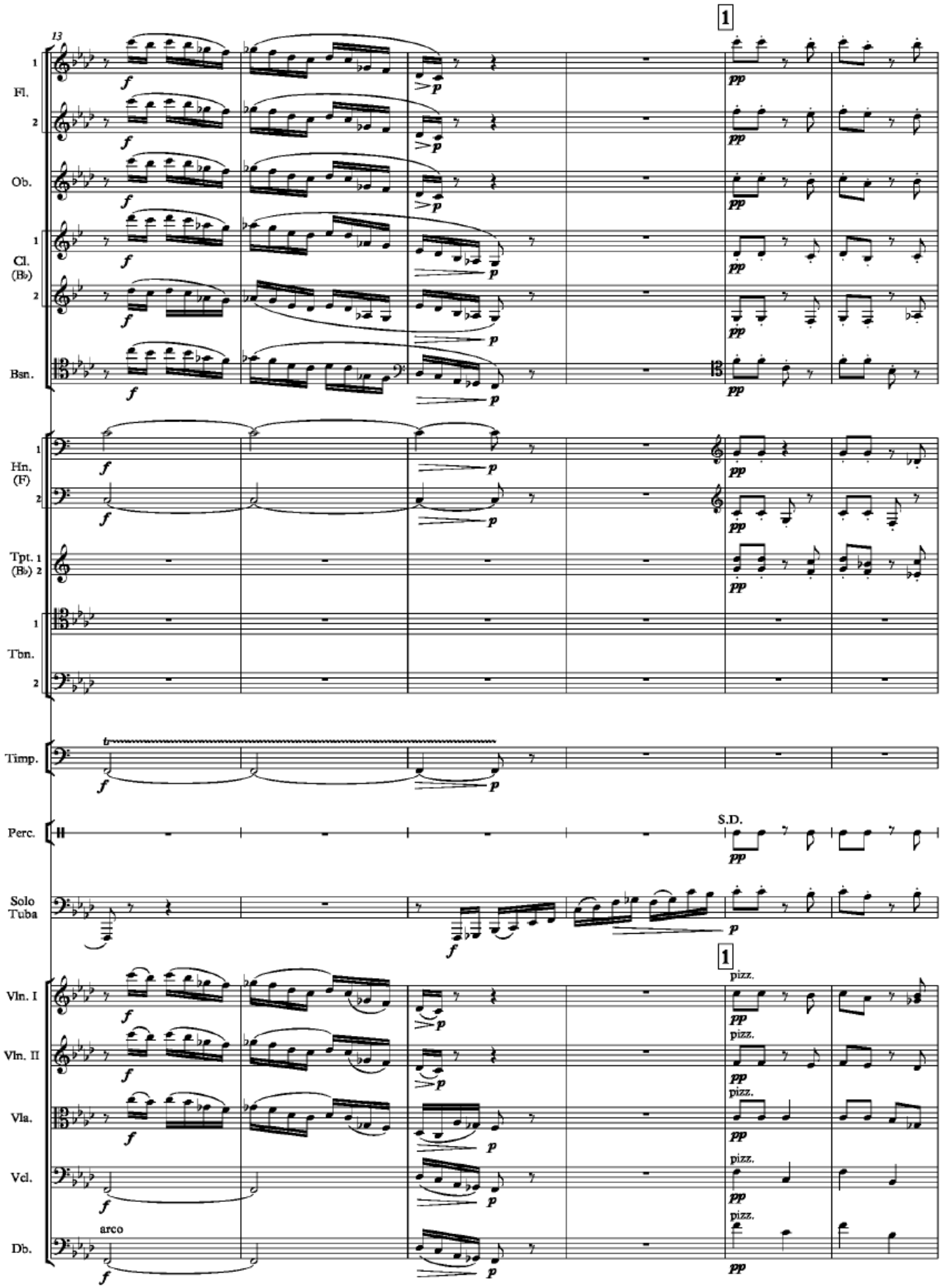
Concerto for Bass Tuba and Orchestra

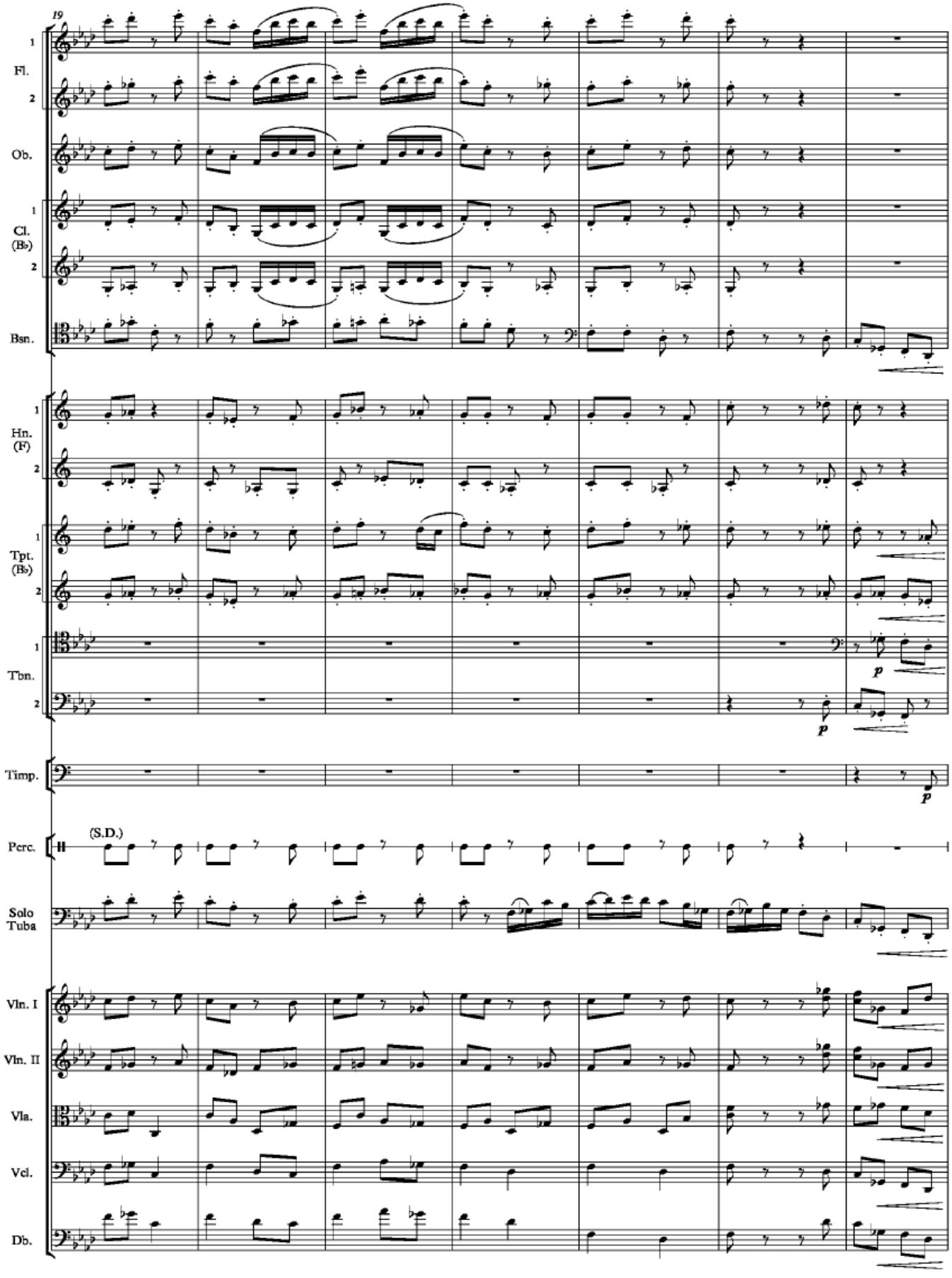
R. VAUGHAN WILLIAMS

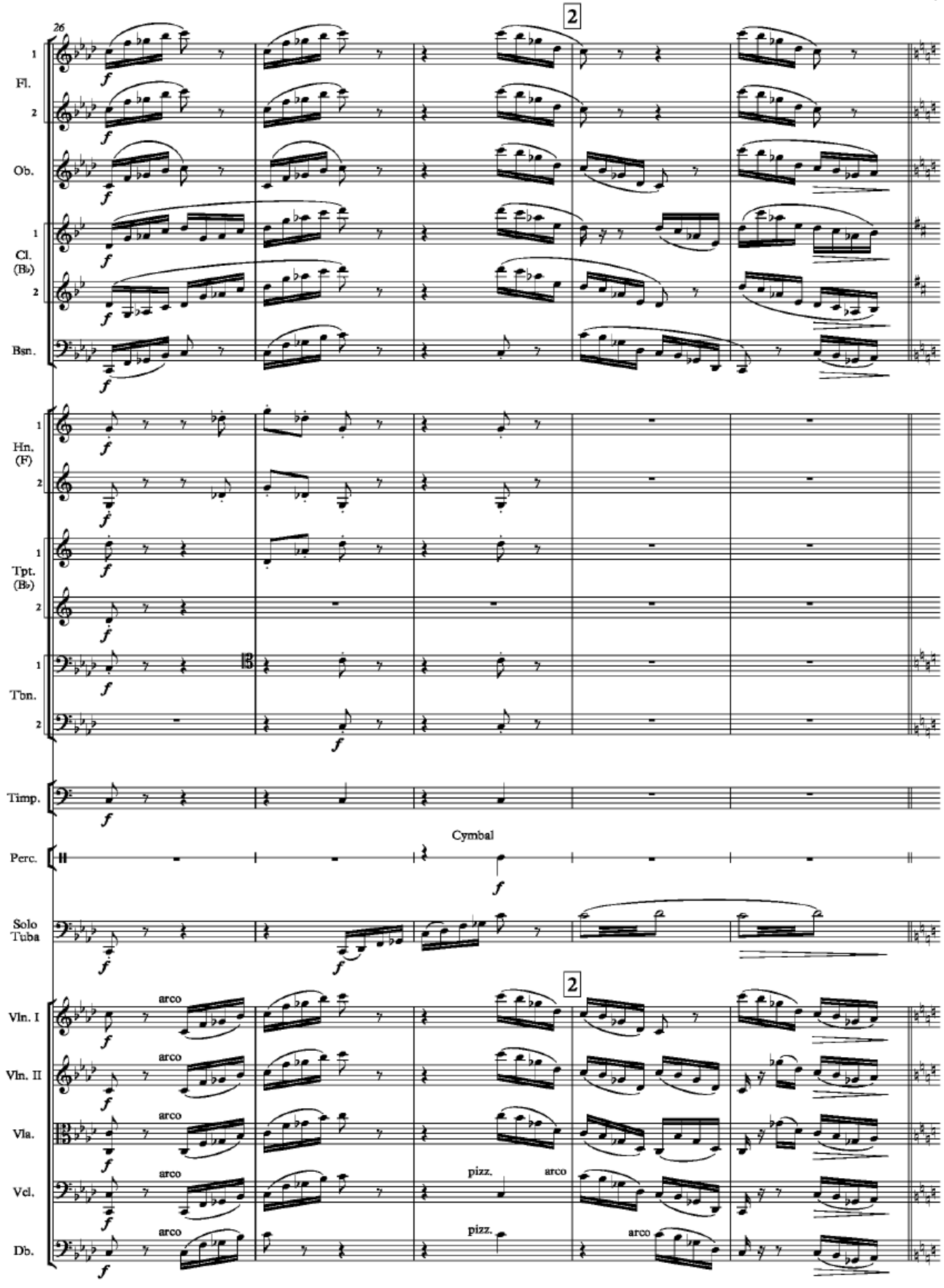
I. Prelude

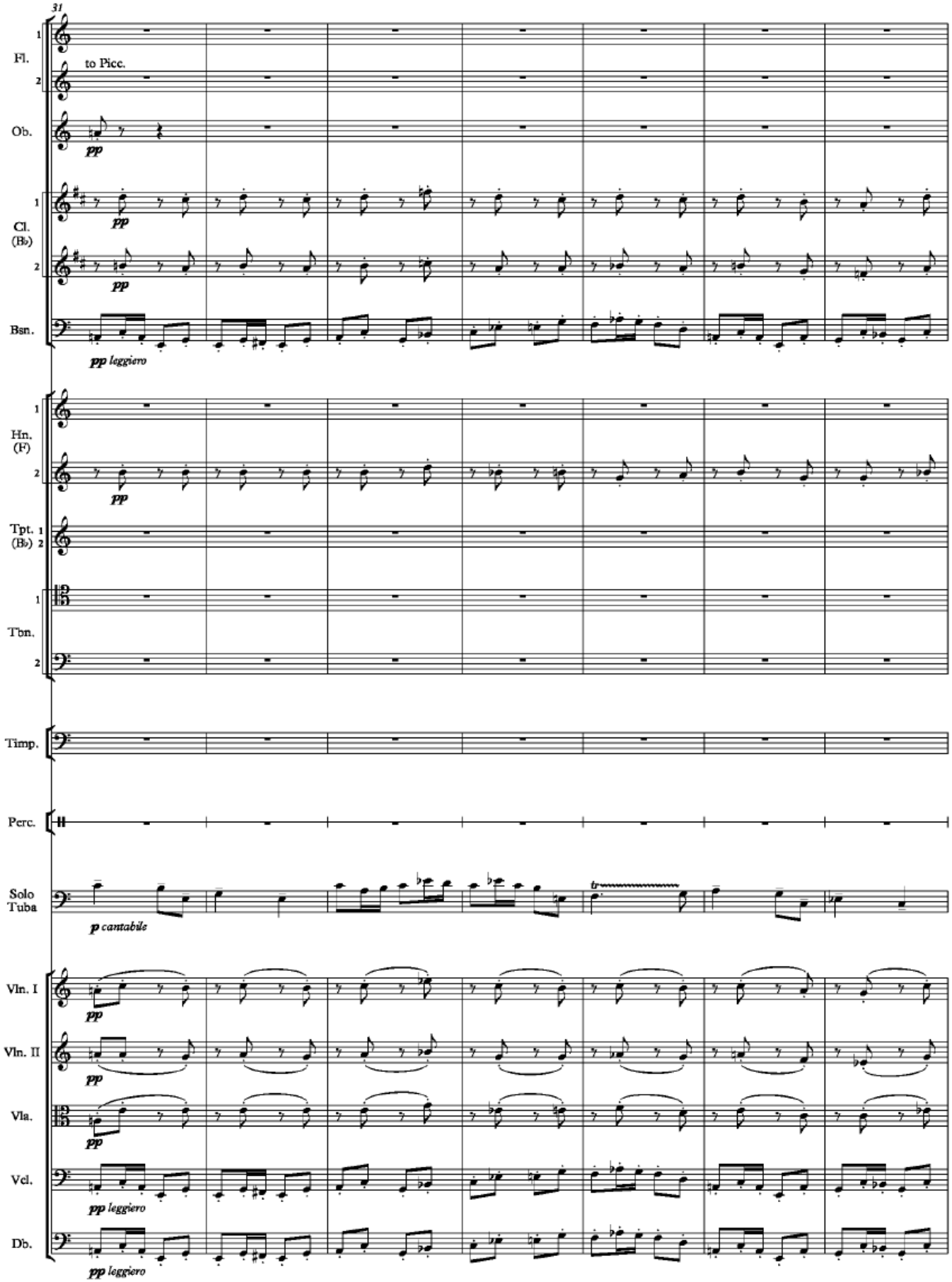


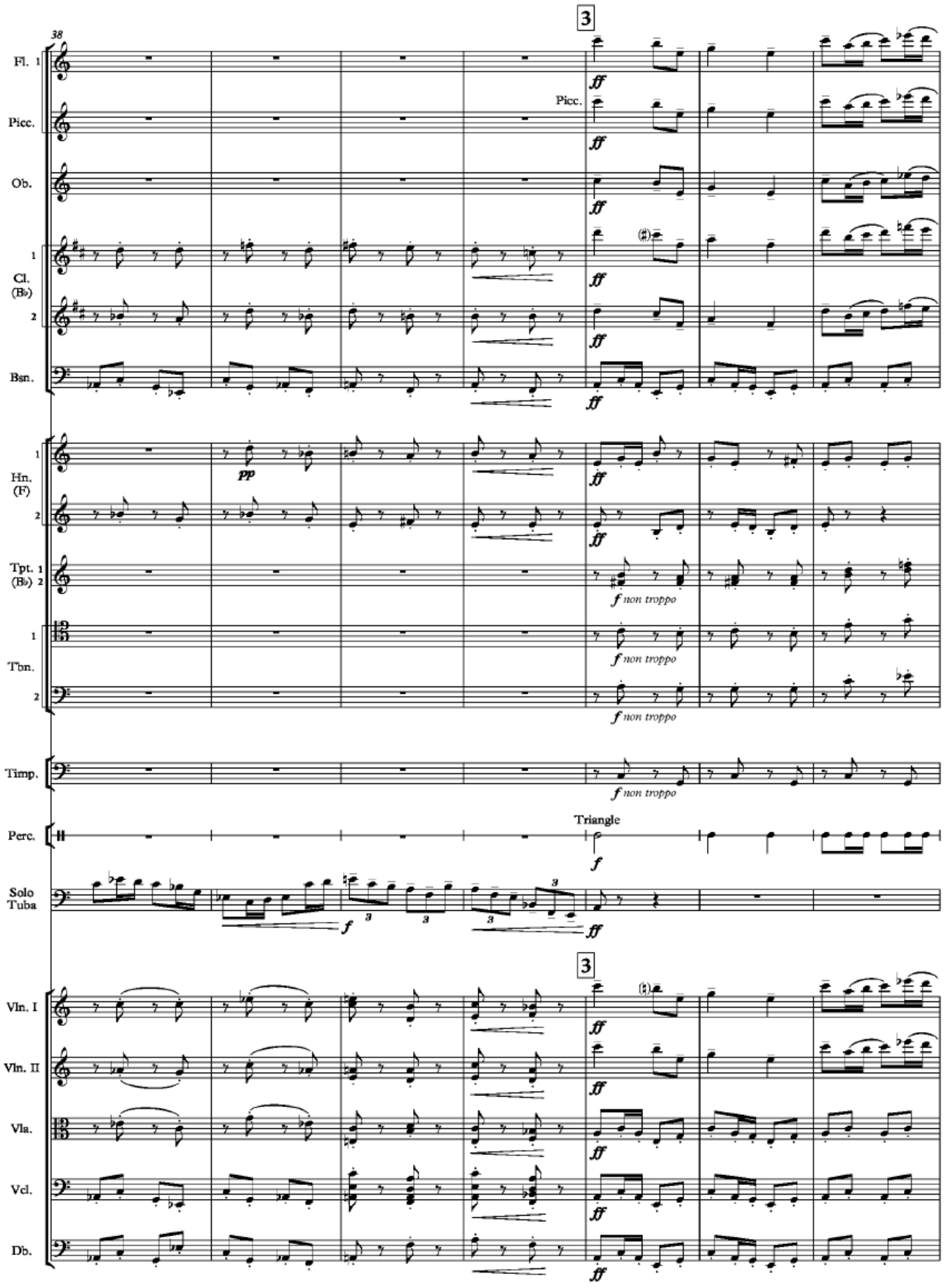

7
1
Fl.
2
Ob.
1
Cl.
(B♭)
2
Bsn.
Hn. 1
(F) 2
Tpt. 1
(B♭) 2
1
Tbn.
2
Timp.
Perc.
Solo
Tuba
cresc.
Vln. I
Vln. II
Vla.
Vcl.
Db.
arco
arco
arco
arco
(sempre pizz.)

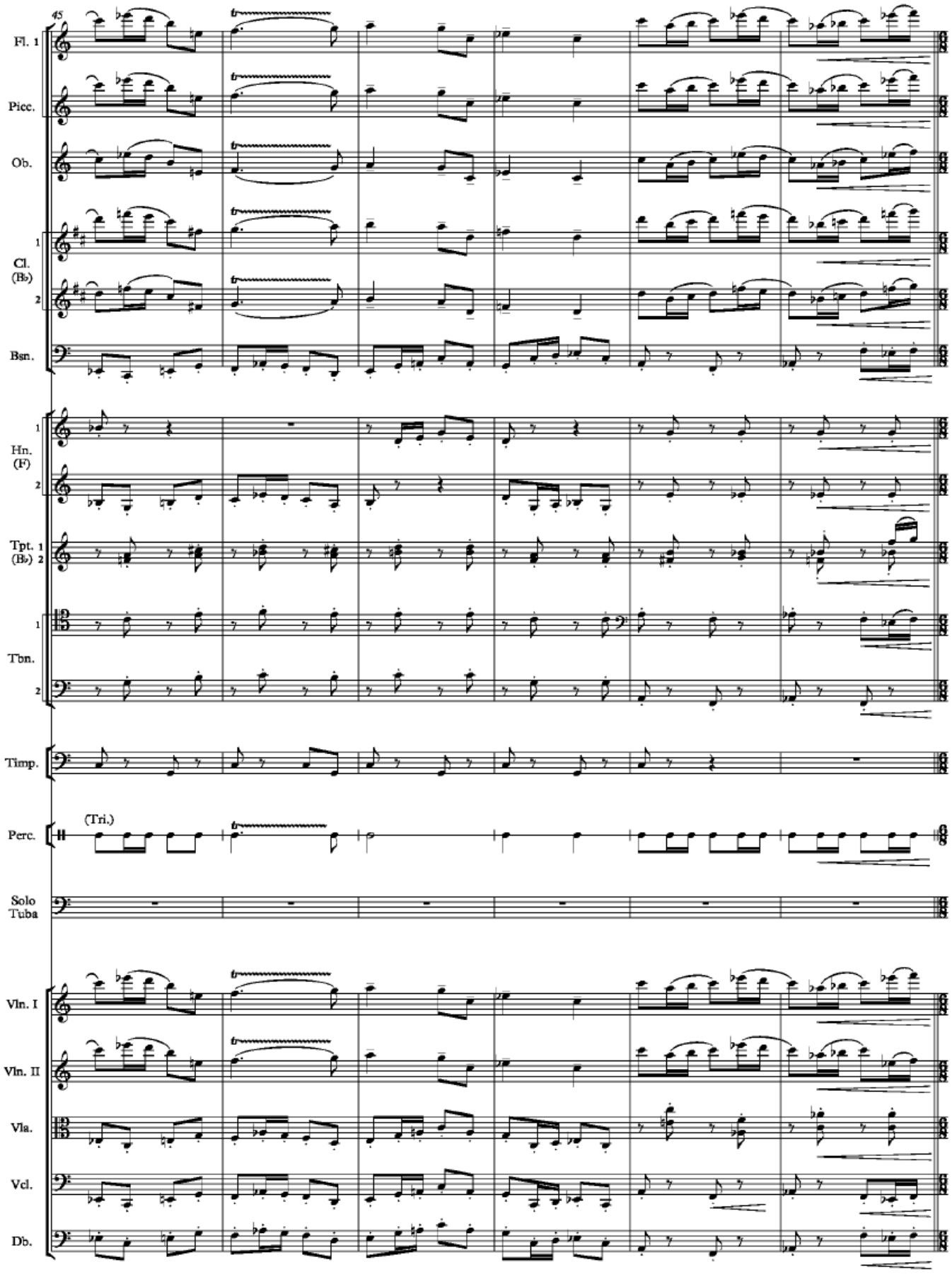

13
1
Fl.
2
Ob.
1
Cl. (B♭)
2
Bsn.
1
Hn. (F)
2
Tpt. 1 2 (B♭)
1
Tbn.
2
Timp.
Perc.
S.D.
Solo Tuba
1
Vln. I
Vln. II
Vla.
Vcl.
Db.
arco
pizz.

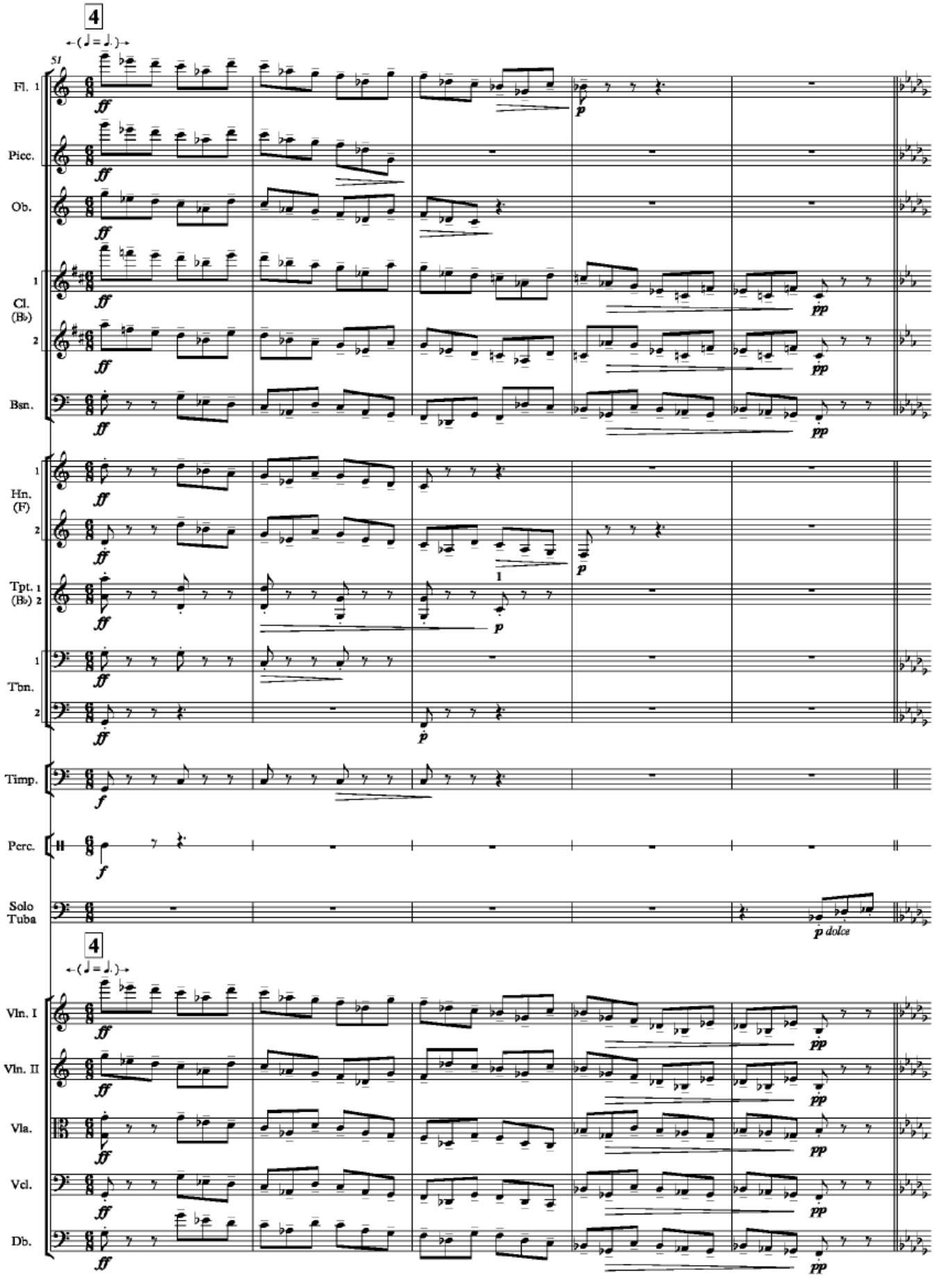

19
1
Fl.
2
Ob.
1
Cl.
(B♭)
2
Bsn.
1
Hn.
(F)
2
1
Tpt.
(B♭)
2
1
Tbn.
2
Timp.
(S.D.)
Perc.
Solo
Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
p
p
p

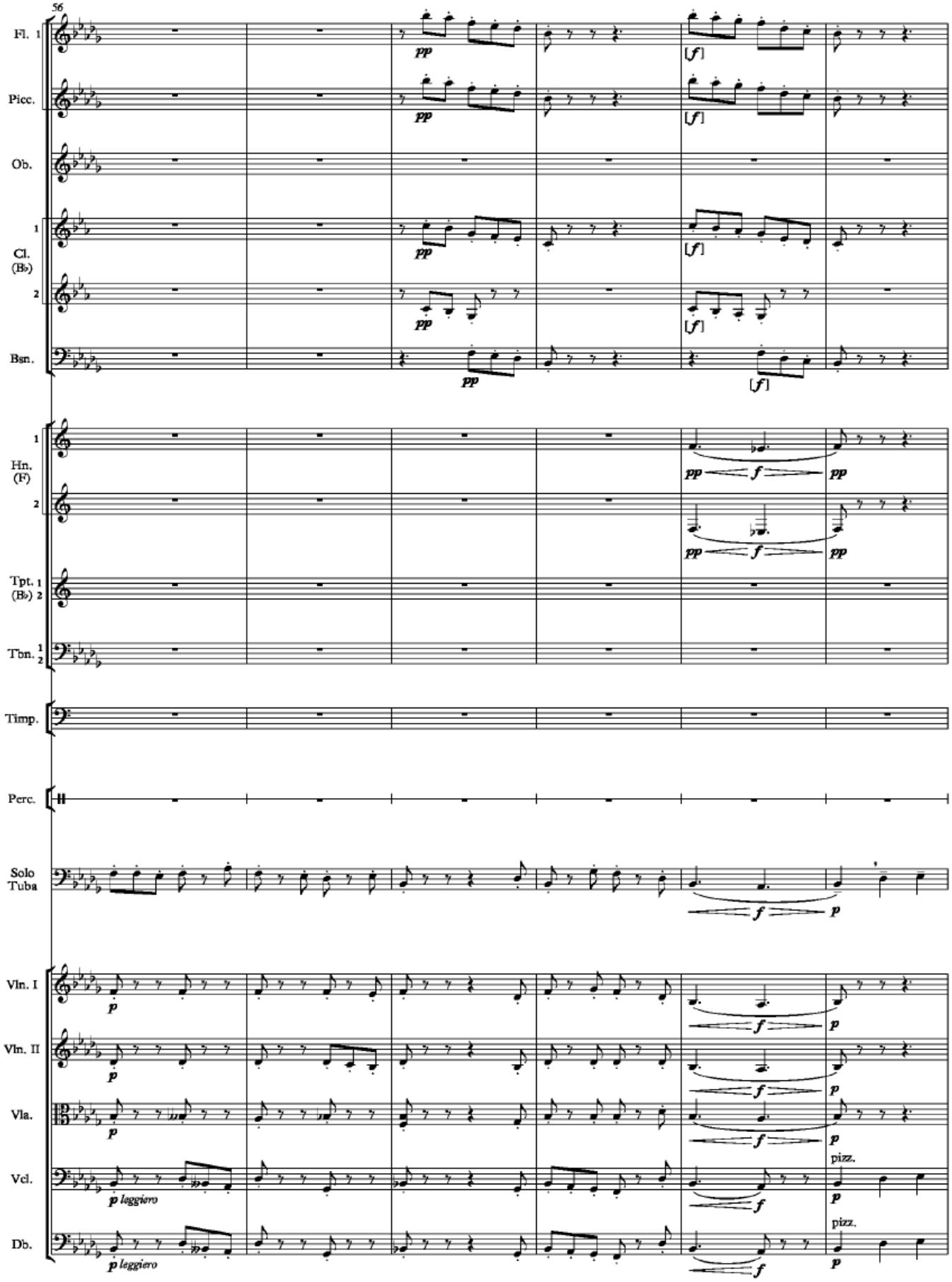

26
2
Fl.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Timp.
Perc.
Cymbal
Solo Tuba
2
Vln. I
Vln. II
Vla.
Vcl.
Db.
arco
pizz.
arco

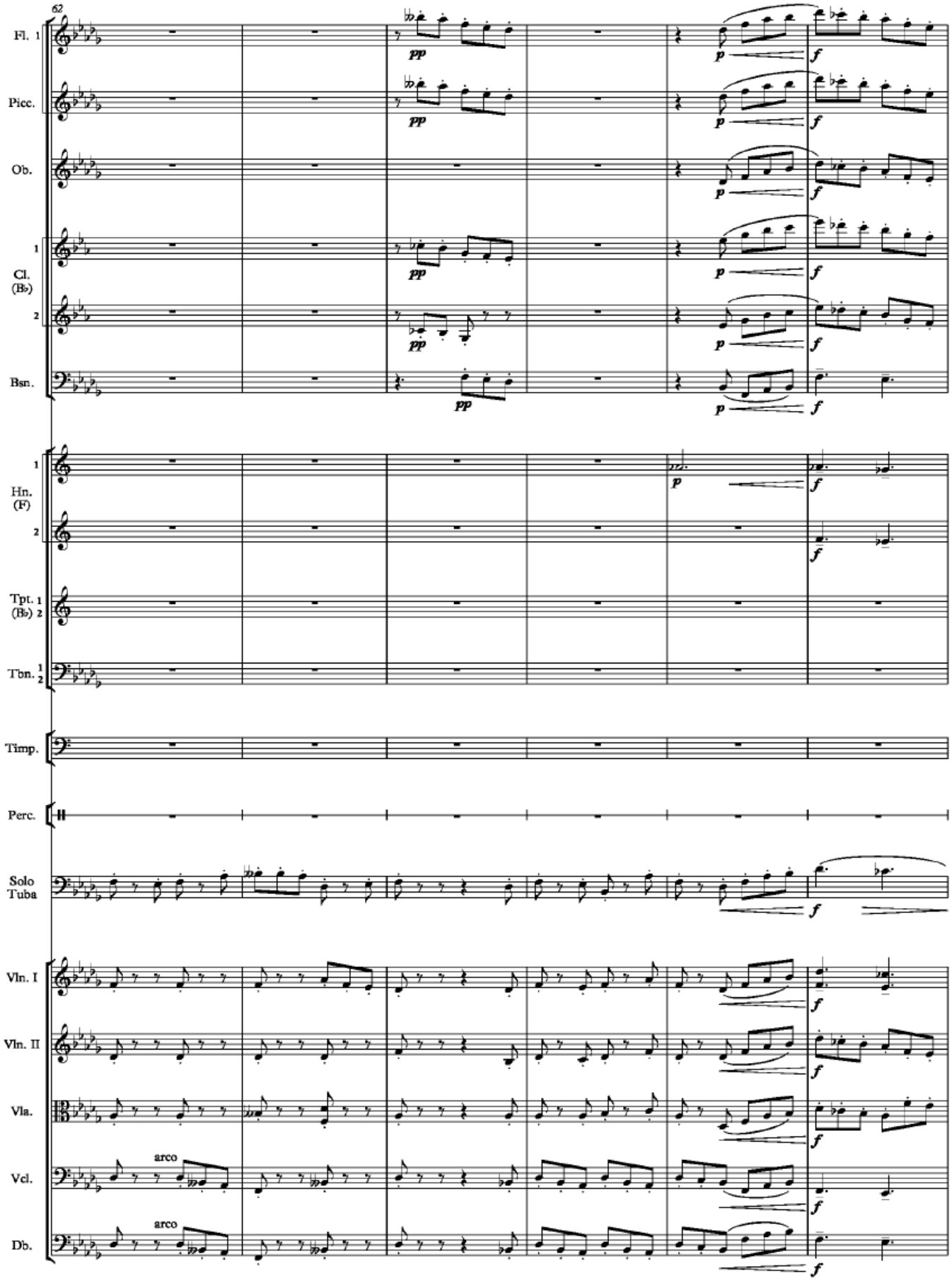

31
Fl.
to Picc.
Ob.
pp
Cl. (B♭)
pp
pp
Bsn.
pp leggiero
Hn. (F)
pp
Tpt. (B♭)
Tbn.
Timp.
Perc.
Solo Tuba
p cantabile
Vln. I
pp
Vln. II
pp
Vla.
pp
Vcl.
pp leggiero
Db.
pp leggiero

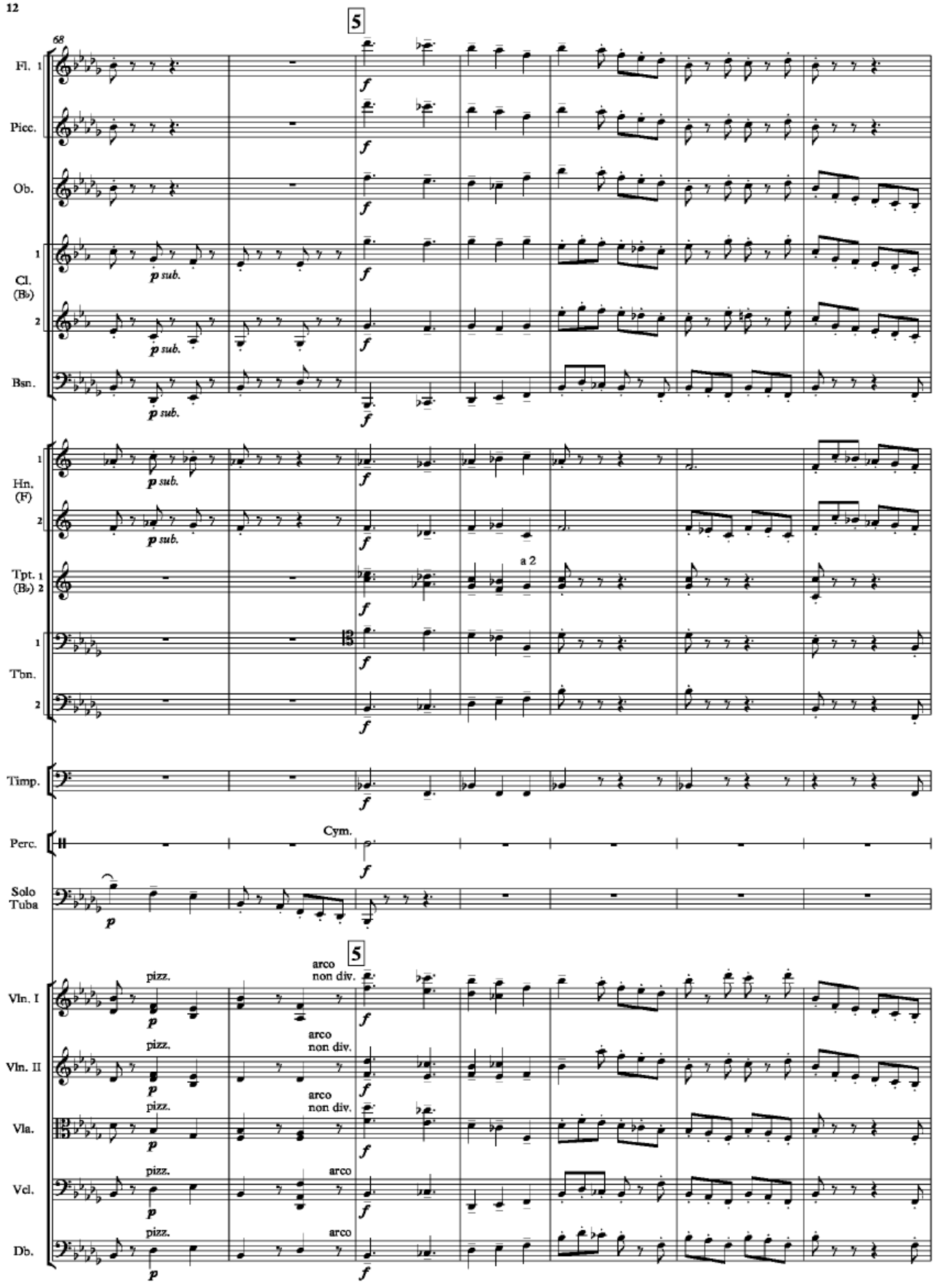

38
3
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1
2
Tbn. 1
2
Timp.
Perc.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
pp
f
ff
f non troppo
Triangle

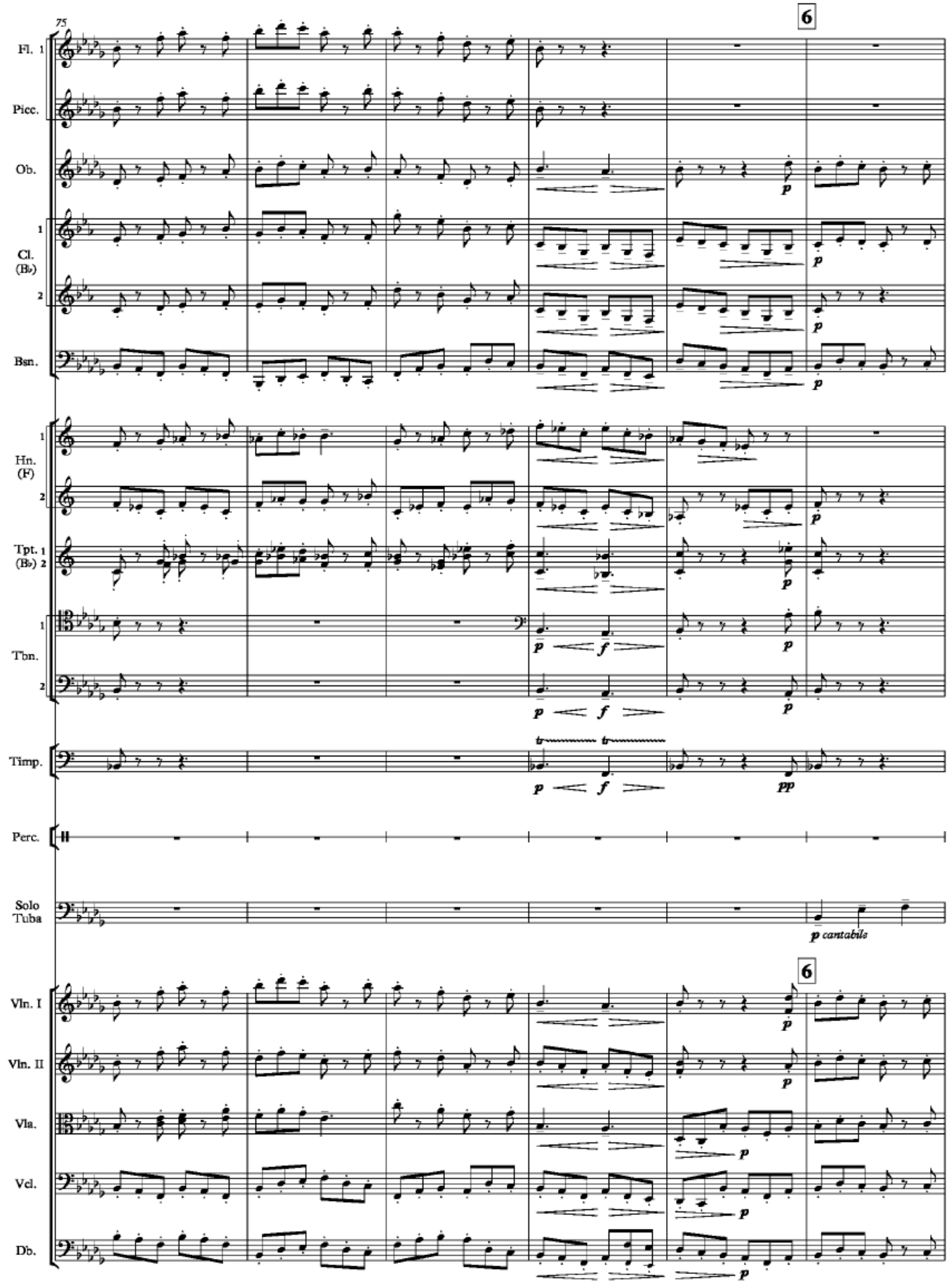

45
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. 1 2 (B♭)
Tbn. 1
2
Timp.
(Tri.)
Perc.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.

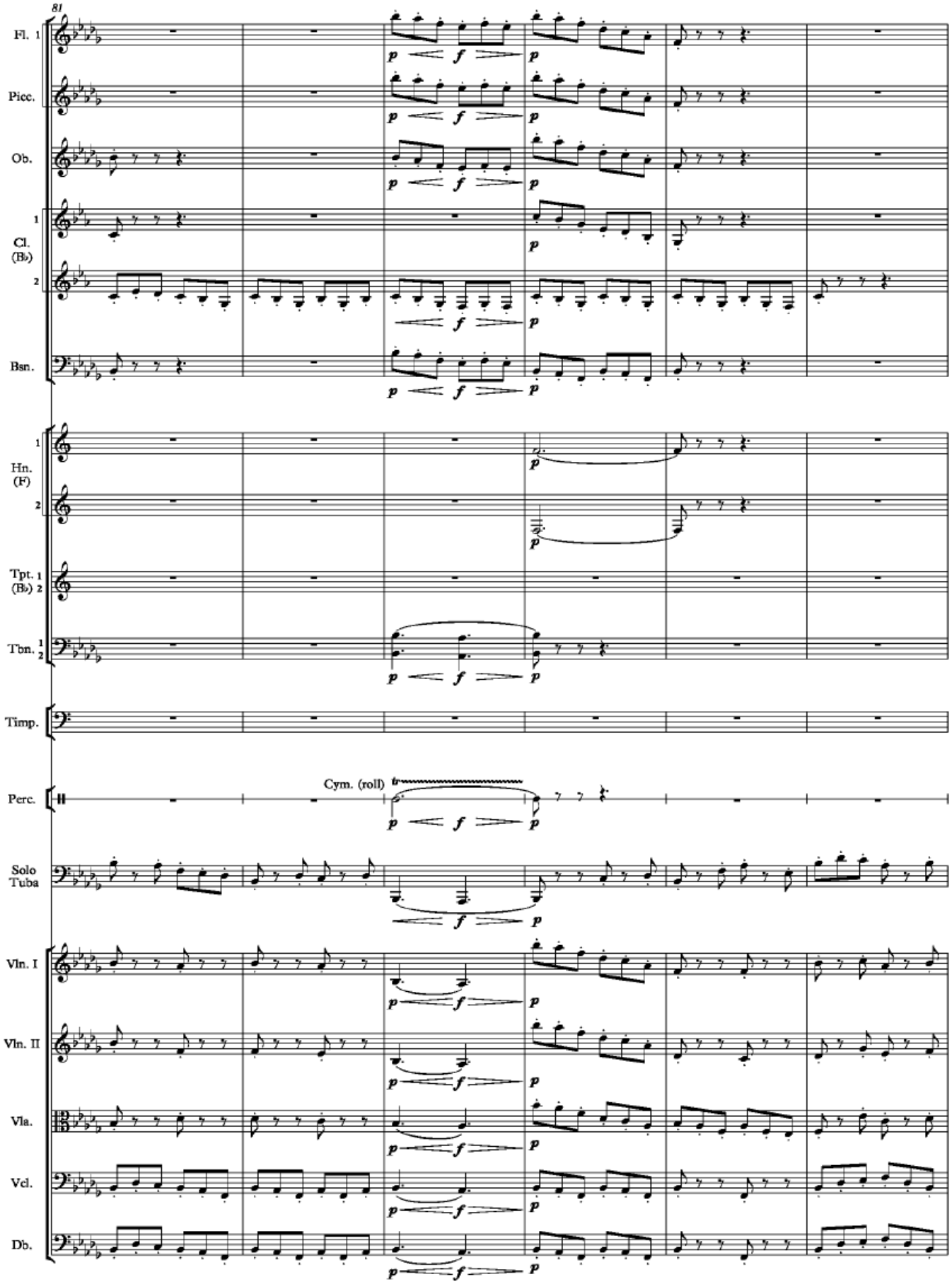

4
(♩ = ♩.)
51
Fl. 1
Picc.
Ob.
Cl. (Bb) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (Bb) 1 2
Tbn. 1
2
Timp.
Perc.
Solo Tuba
p dolce
4
(♩ = ♩.)
Vln. I
Vln. II
Vla.
Vcl.
Db.

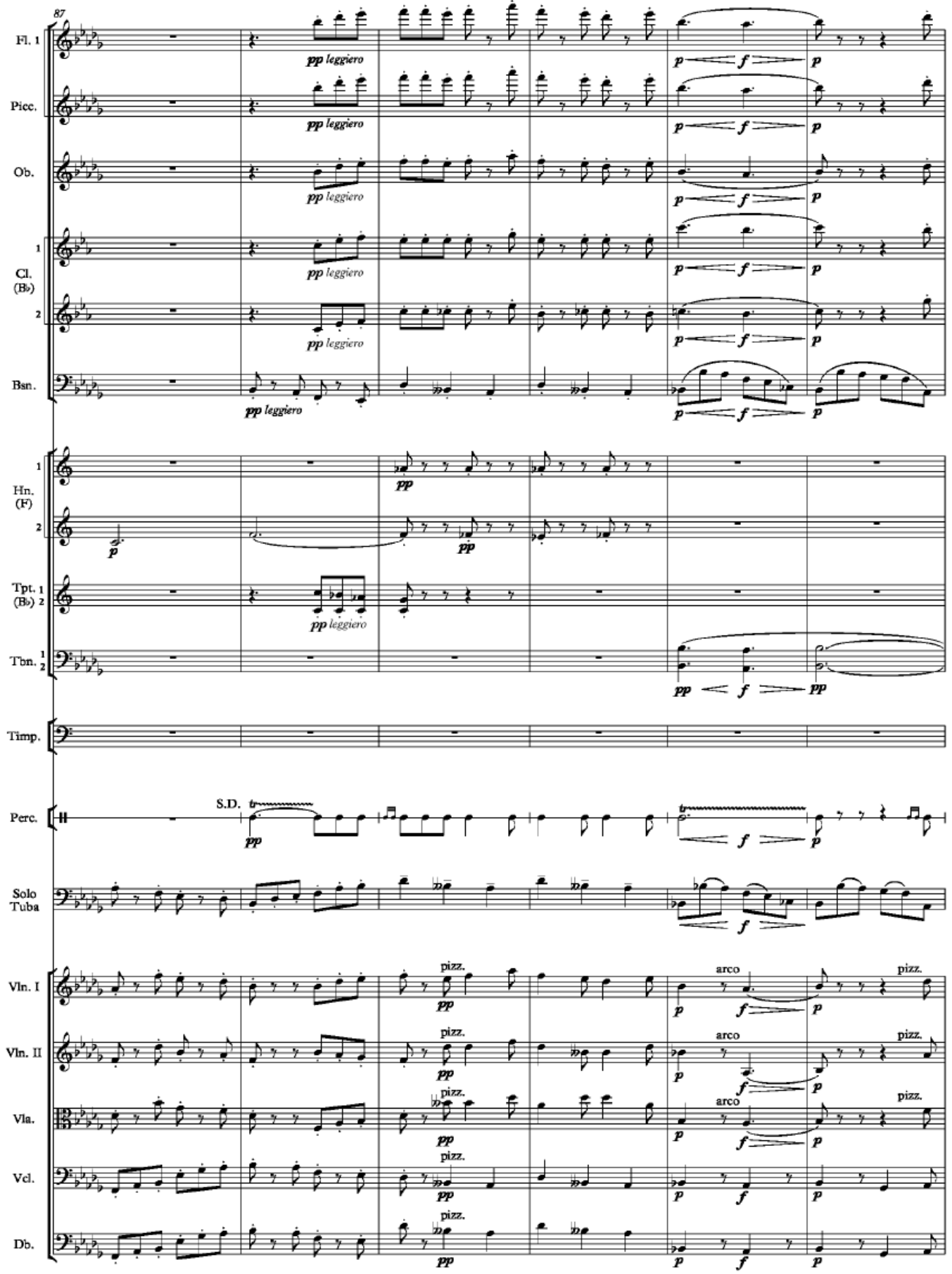

56
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
Cl. (B♭) 2
Bsn.
Hn. (F) 1
Hn. (F) 2
Tpt. (B♭) 1 2
Tbn. 1 2
Timp.
Perc.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
pp
[f]
f
p
p leggiero
pizz.

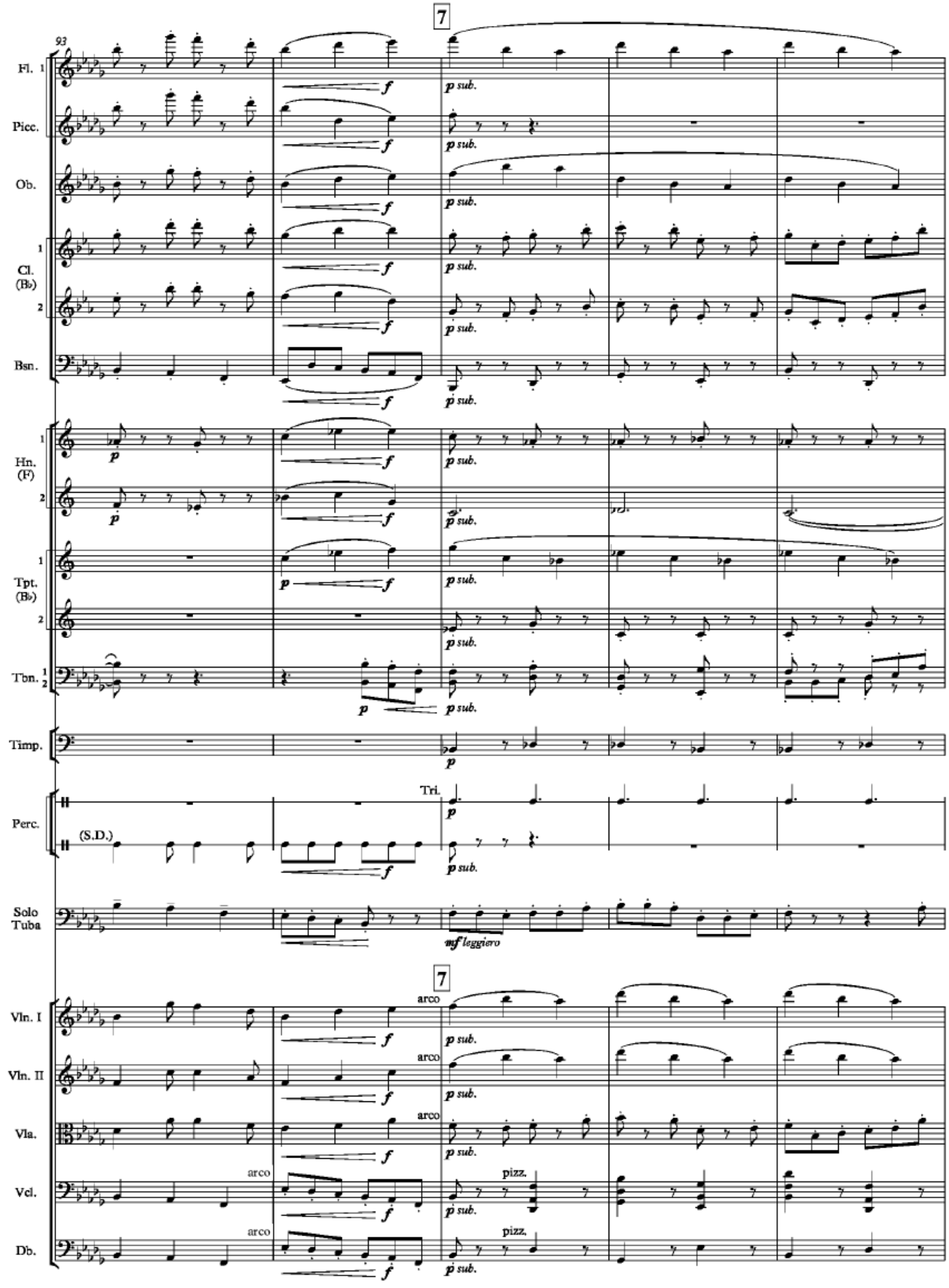

62
Fl. 1
Picc.
Ob.
1
Cl. (B♭)
2
Bsn.
1
Hn. (F)
2
Tpt. 1 2 (B♭)
Tbn. 1 2
Timp.
Perc.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
arco
arco
pp
p
f

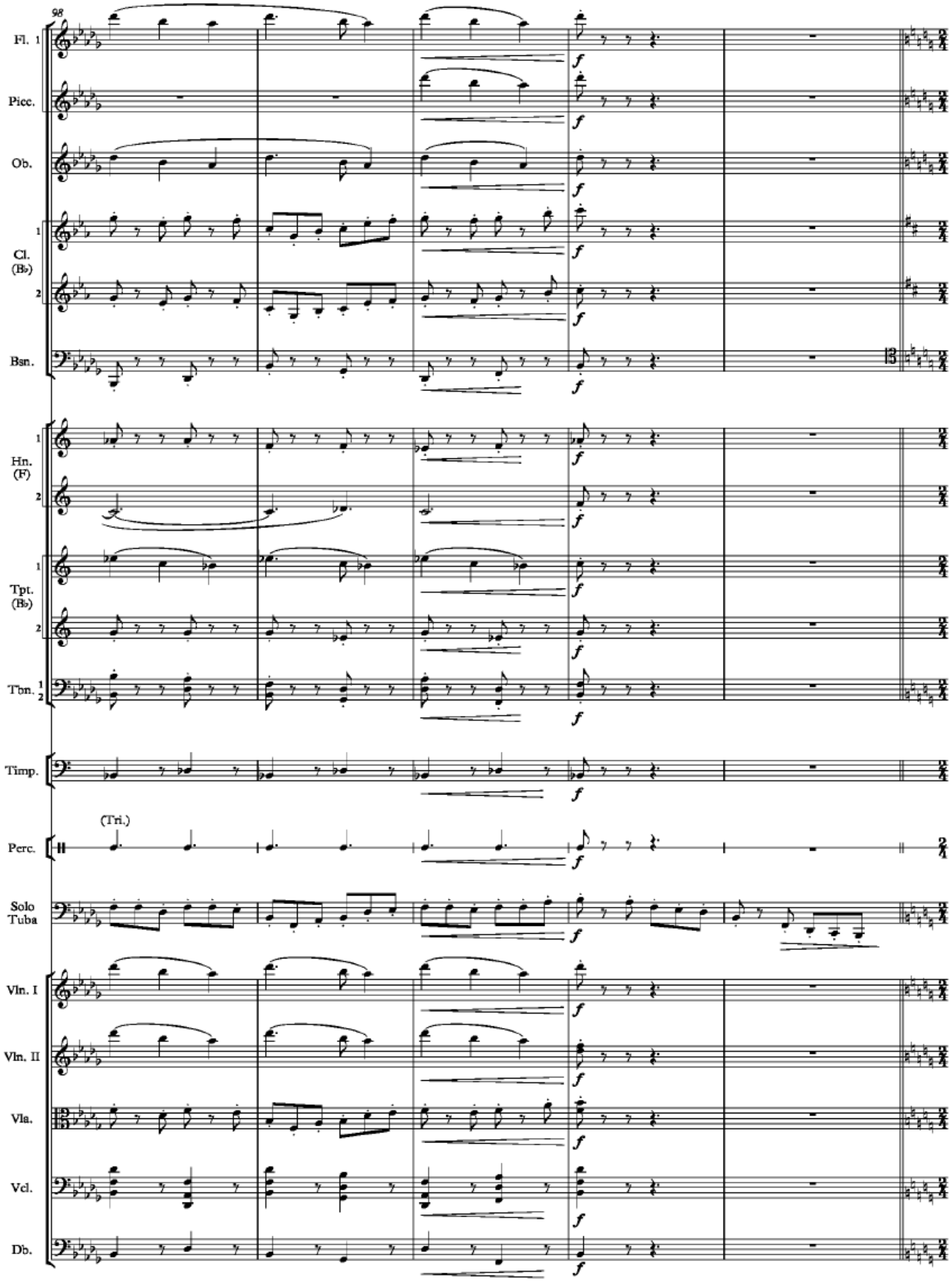

68
5
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
Cl. (B♭) 2
Bsn.
Hn. (F) 1
Hn. (F) 2
Tpt. (B♭) 1 2
a 2
Tbn. 1
Tbn. 2
Timp.
Perc.
Cym.
Solo Tuba
5
Vln. I
Vln. II
Vla.
Vcl.
Db.
pizz.
arco
non div.
p sub.
f
p

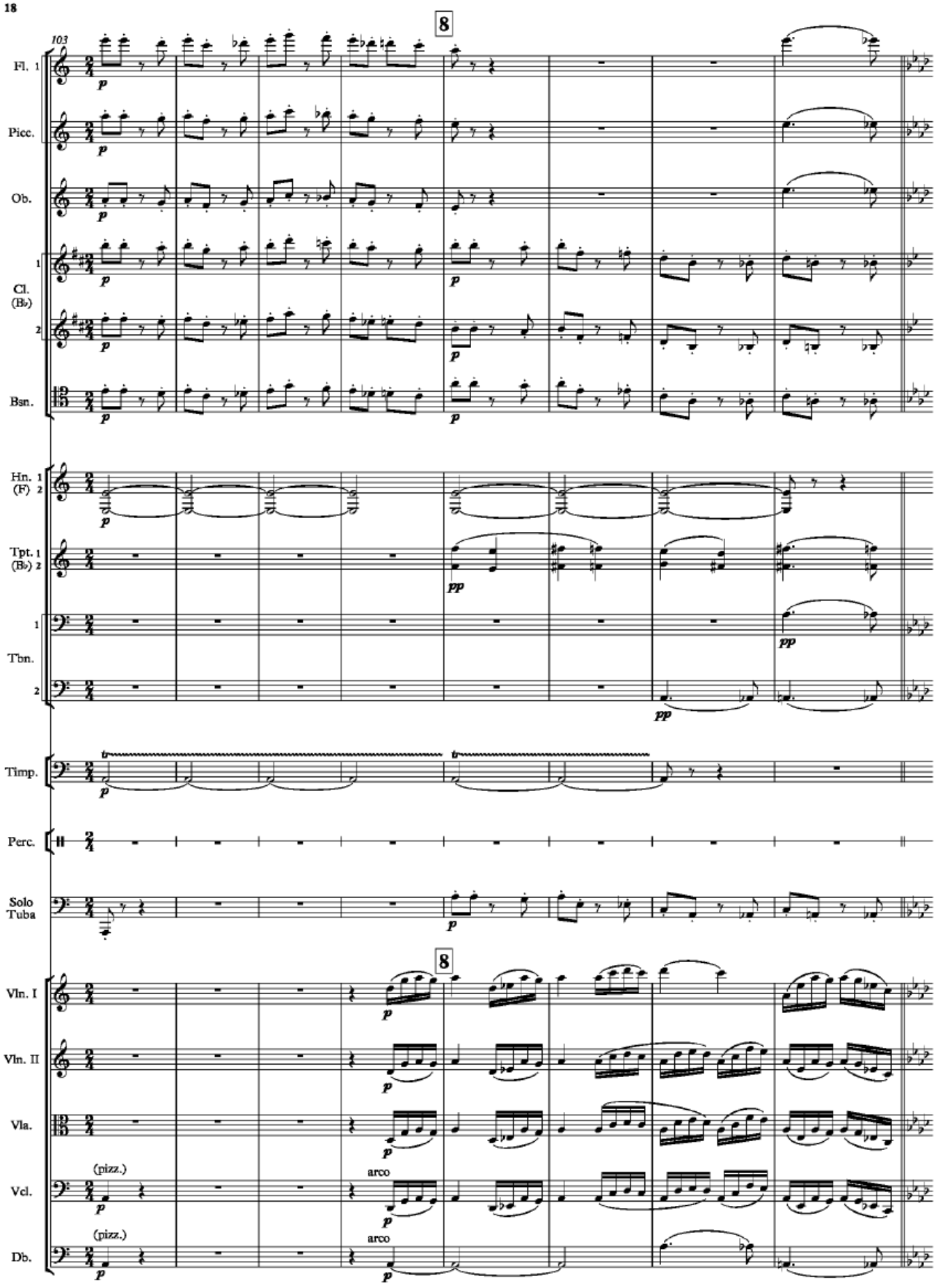

75
6
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1 2
Tbn. 1
2
Timp.
Perc.
Solo Tuba
p cantabile
6
Vln. I
Vln. II
Vla.
Vcl.
Db.

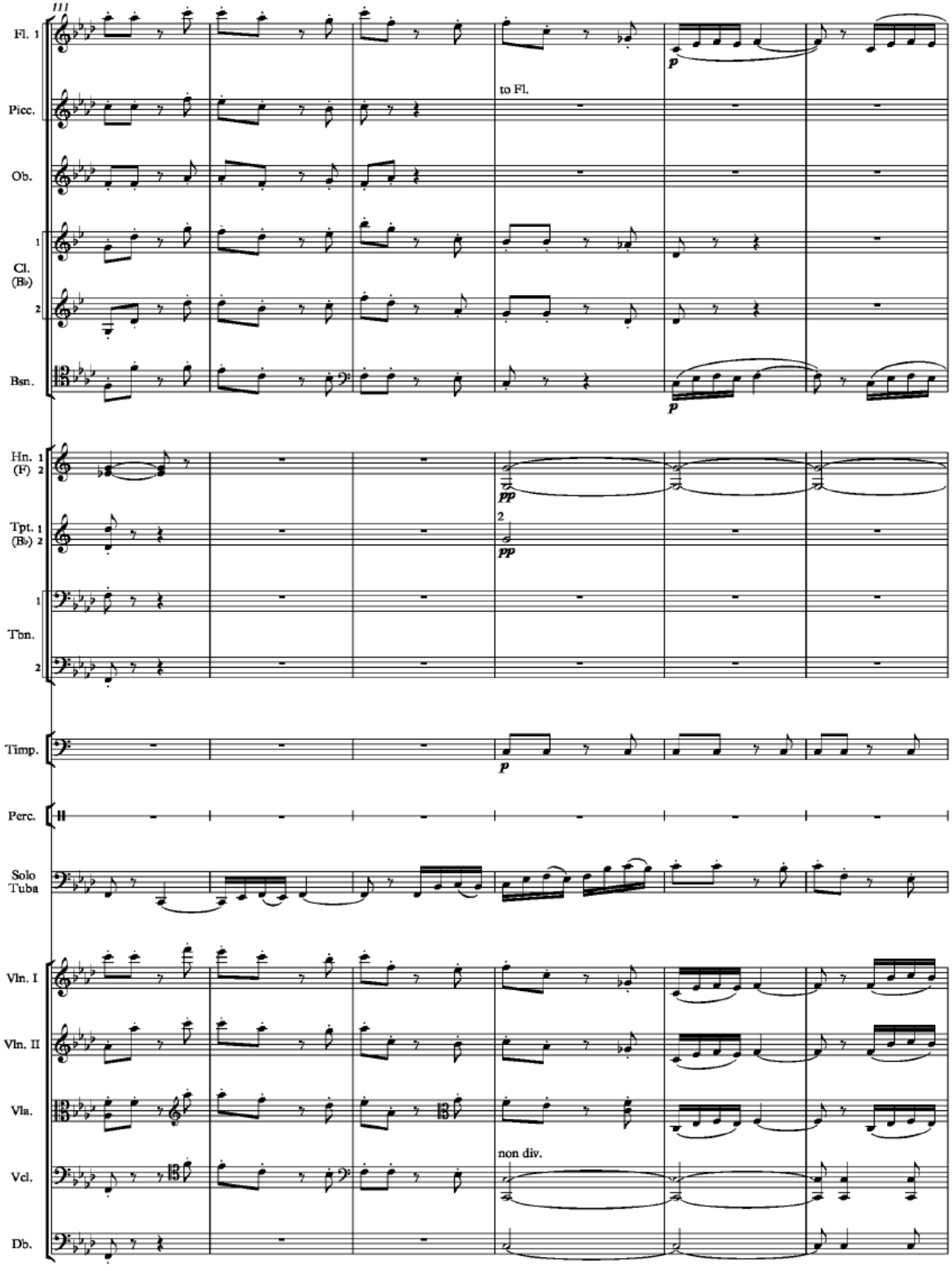

81
Fl. 1
Picc.
Ob.
1
Cl. (B♭)
2
Bsn.
1
Hn. (F)
2
Tpt. 1 2 (B♭)
Tbn. 1 2
Timp.
Perc.
Cym. (roll)
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.

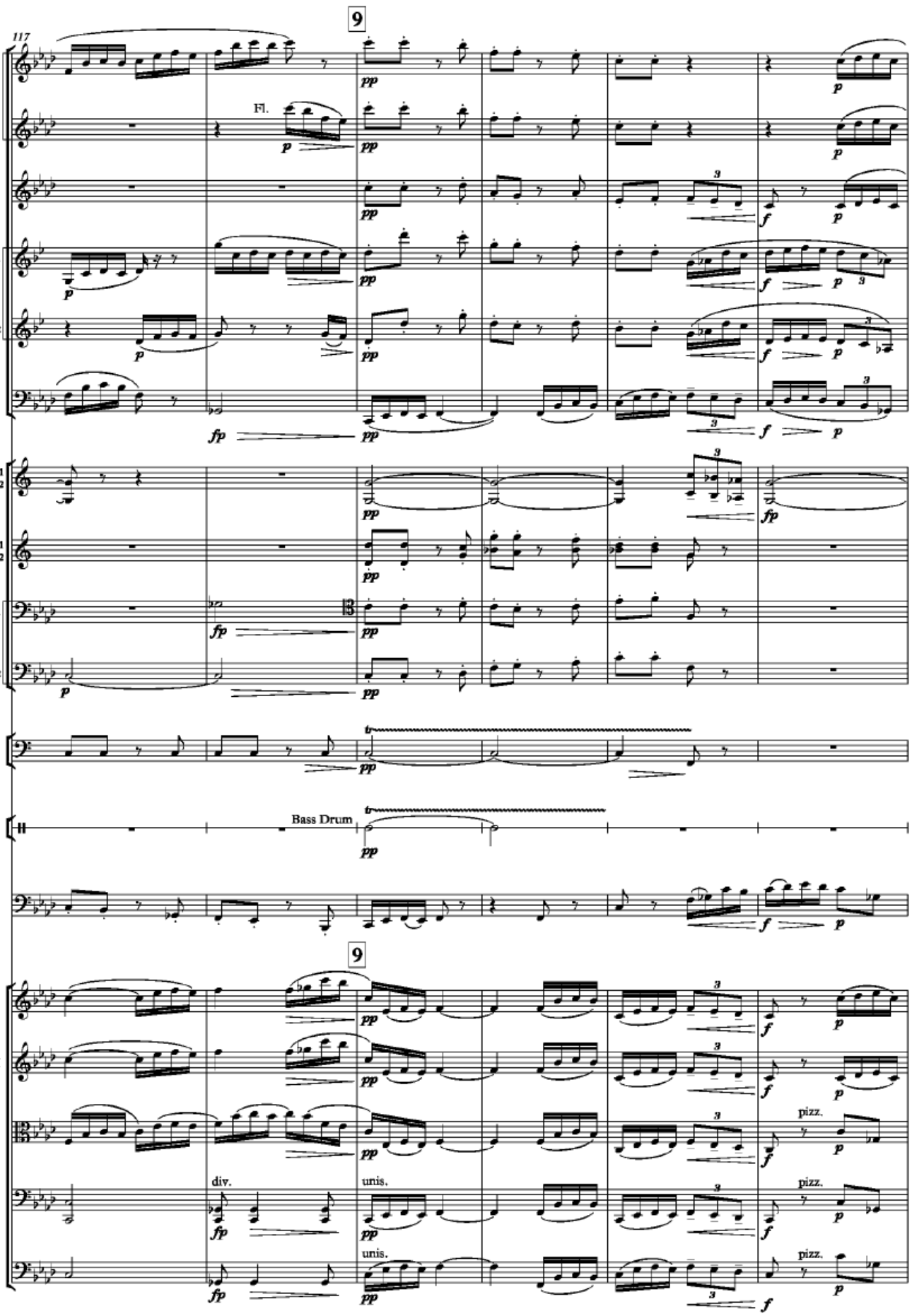

87
Fl. 1
Picc.
Ob.
1
Cl. (B♭)
2
Bsn.
1
Hn. (F)
2
Tpt. 1 2 (B♭)
Tbn. 1 2
Timp.
Perc.
S.D.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
pp leggiero
p
f
pp
pizz.
arco

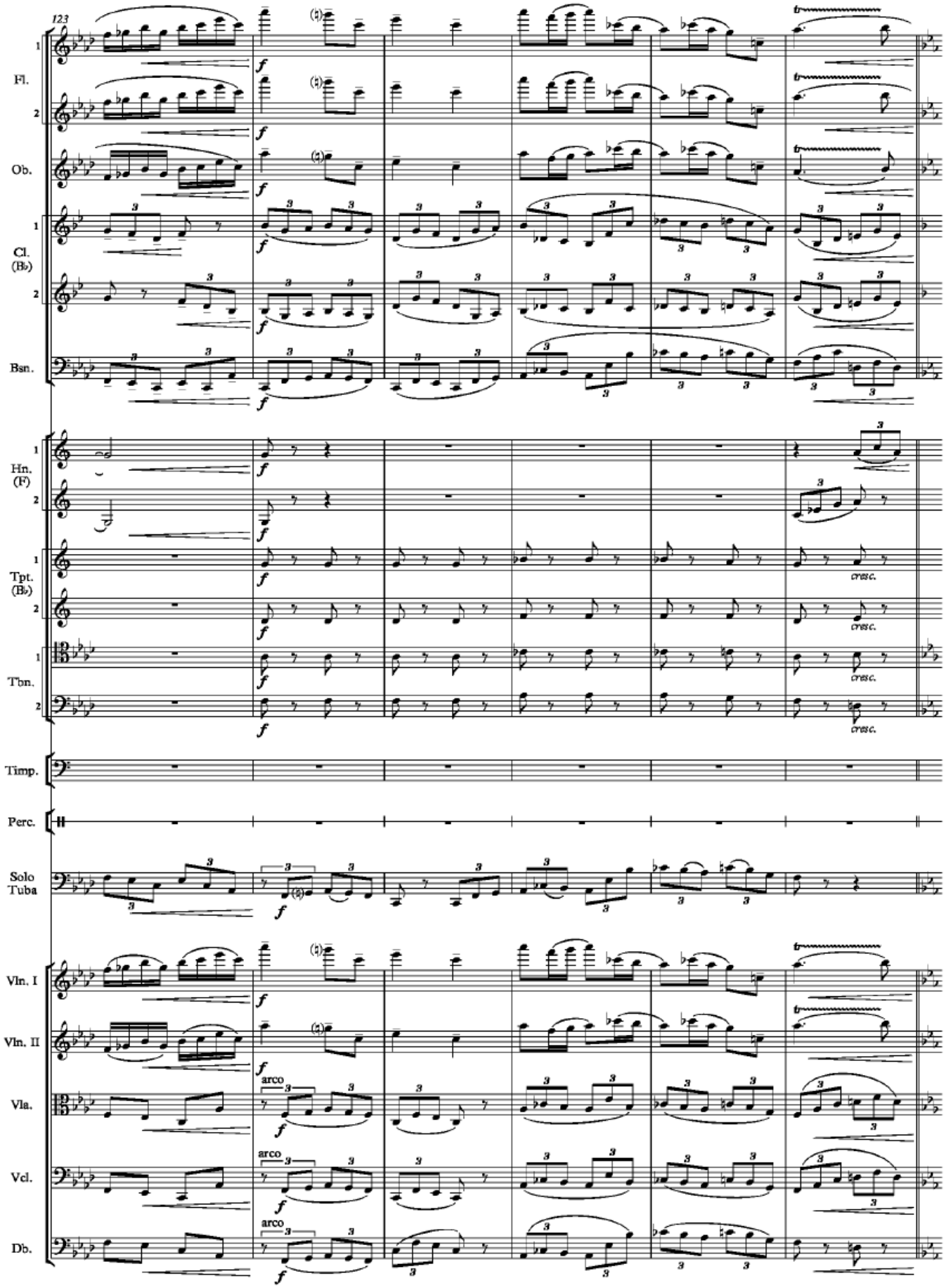

93
7
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1
2
Tbn. 1 2
Timp.
Perc.
(S.D.)
Tri.
Solo Tuba
mf leggiero
7
Vln. I
Vln. II
Vla.
Vcl.
Db.
arco
pizz.
p sub.
f
p

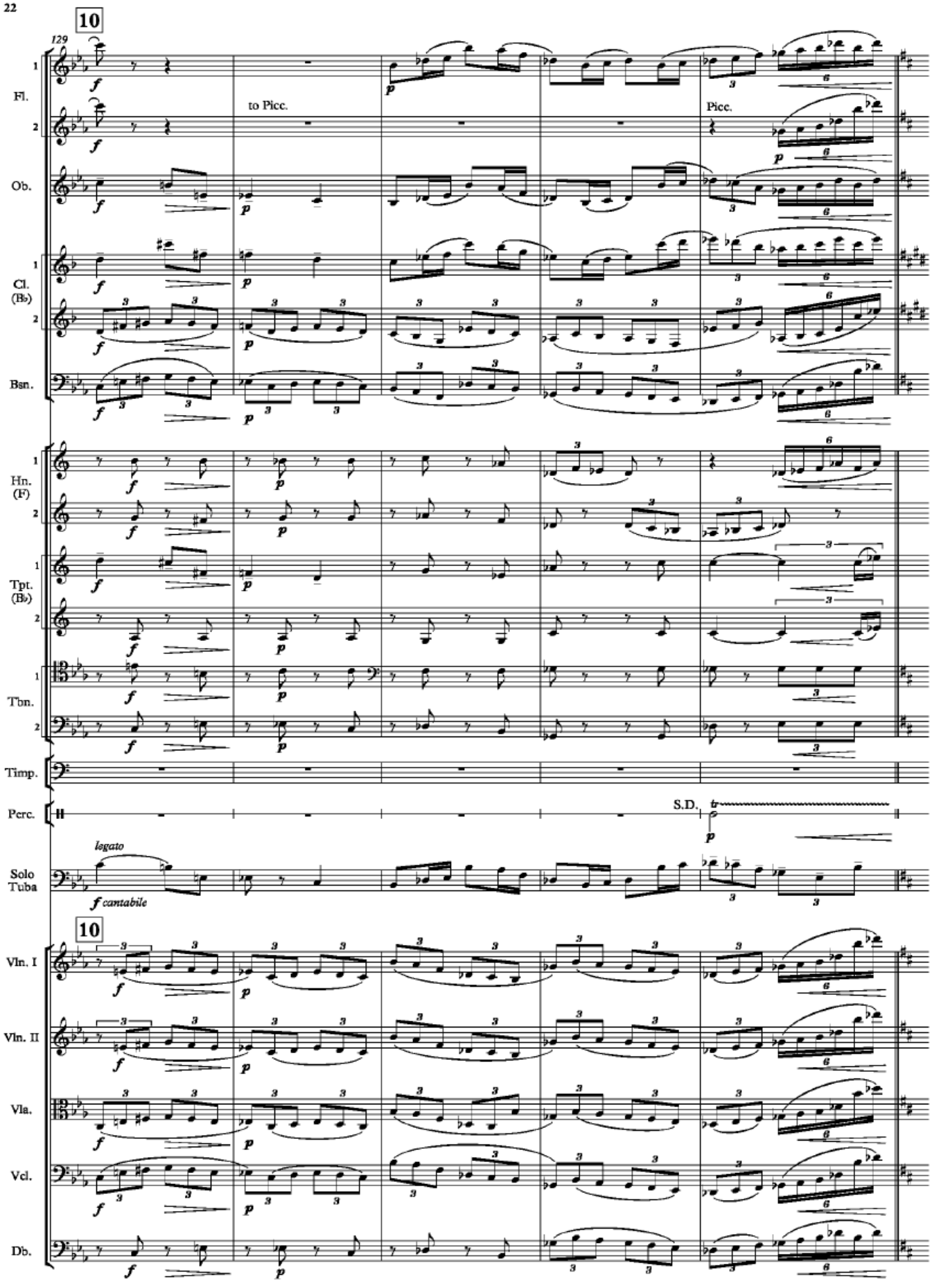

98
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1
2
Tbn. 1
2
Timp.
(Tri.)
Perc.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
f

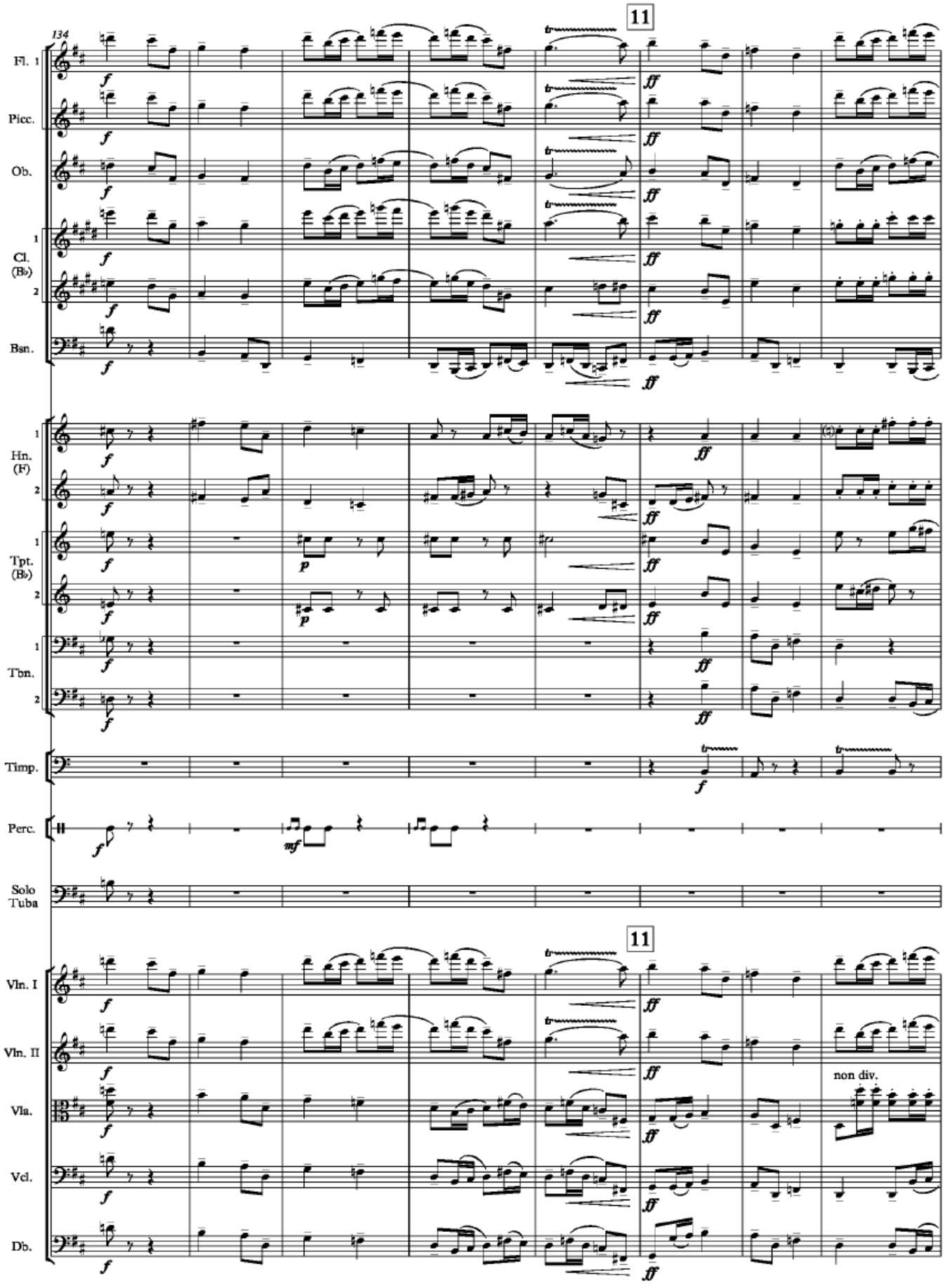

103
8
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
Cl. (B♭) 2
Bsn.
Hn. 1 (F) 2
Tpt. 1 (B♭) 2
Tbn. 1
Tbn. 2
Timp.
Perc.
Solo Tuba
8
Vln. I
Vln. II
Vla.
Vcl.
Db.
(pizz.)
arco
(pizz.)
arco

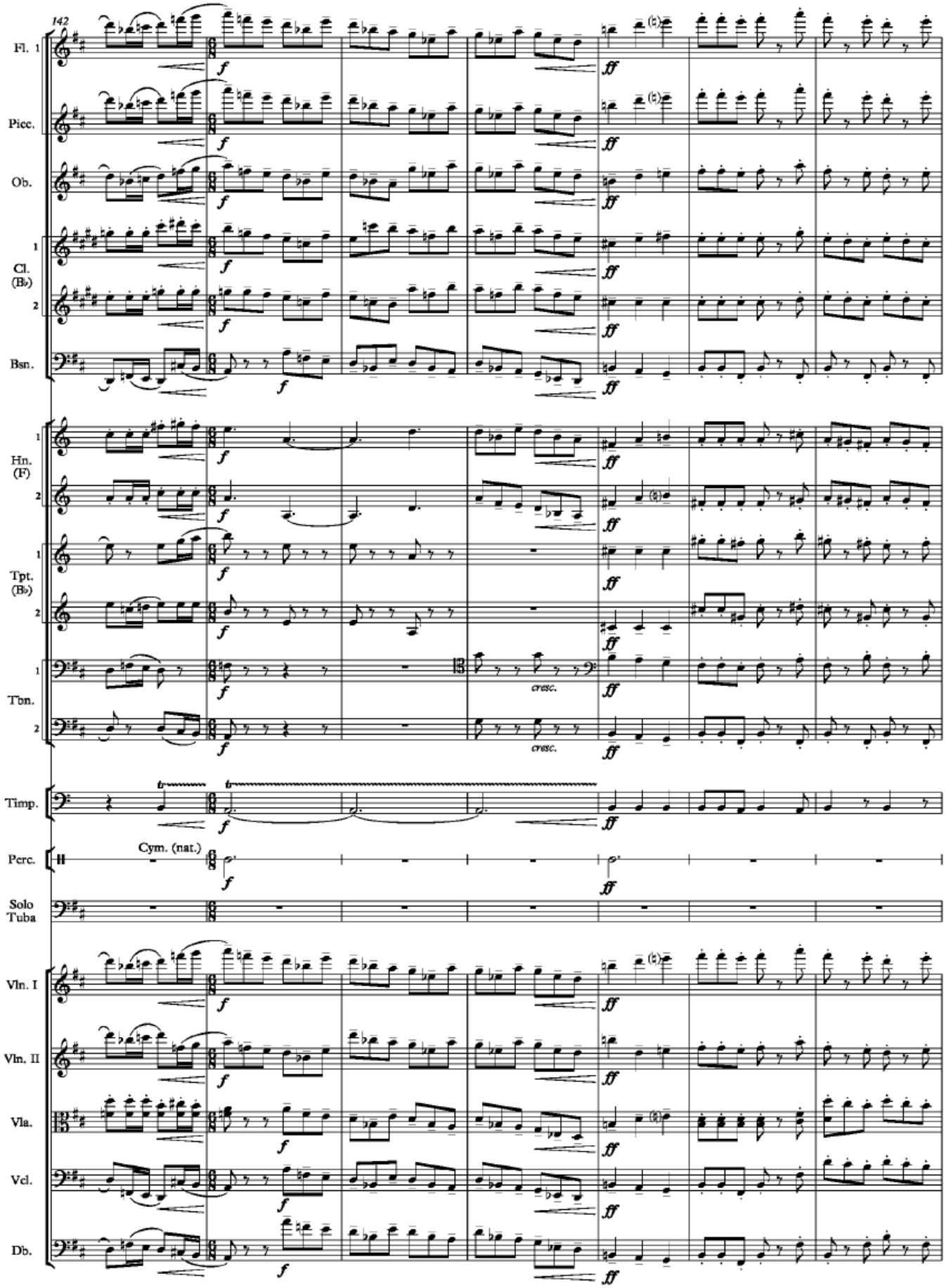

111
Fl. 1
Picc.
to Fl.
Ob.
Cl. (B♭) 1
2
Bsn.
p
Hn. (F) 1 2
pp
Tpt. (B♭) 1 2
2
Tbn. 1
2
Timp.
Perc.
Solo Tuba
Vln. I
Vln. II
Vla.
non div.
Vcl.
Db.

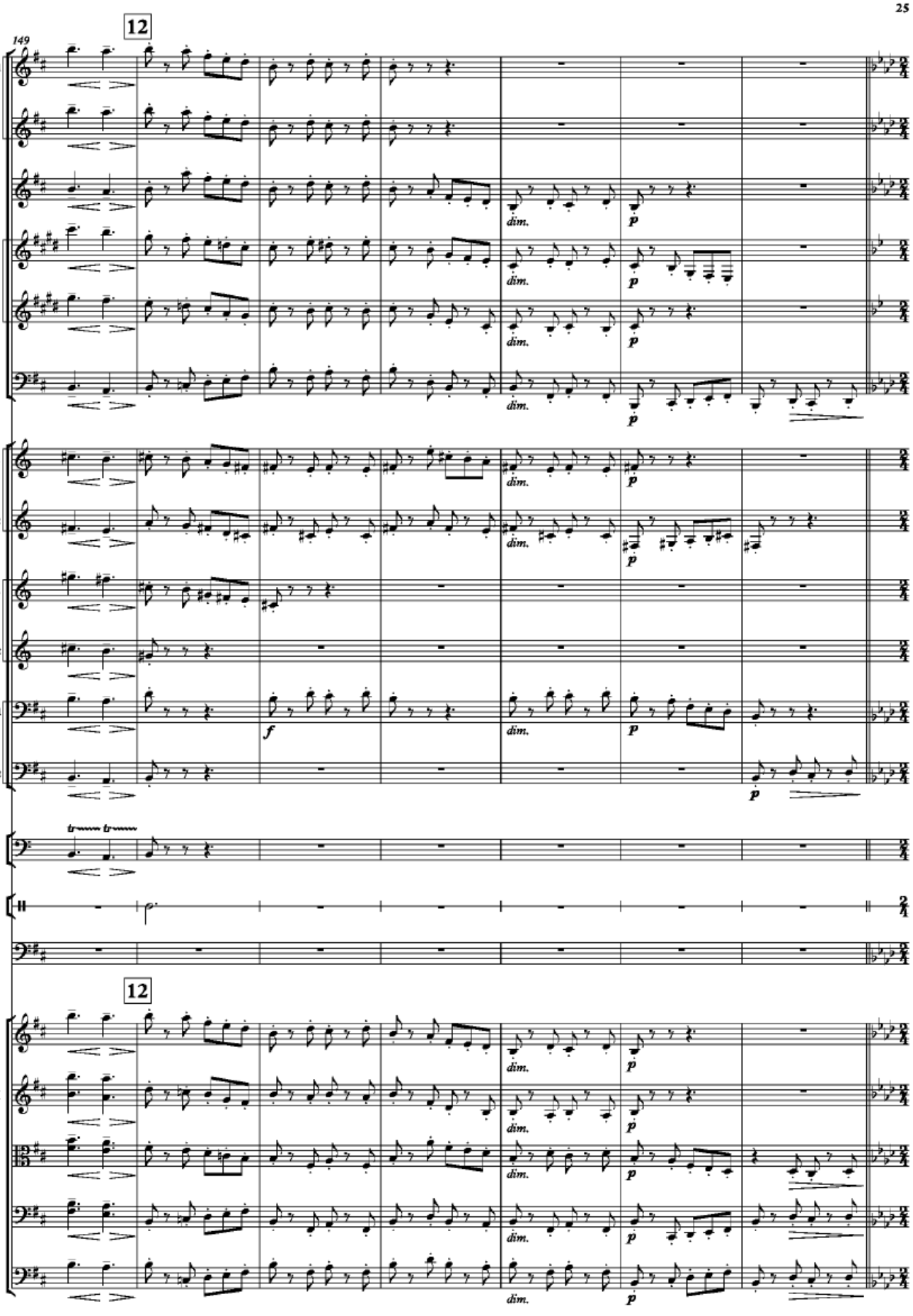

117
9
Fl. 1
Fl. 2
Ob.
Cl. (B♭) 1
Cl. (B♭) 2
Bsn.
Hn. 1 (F) 2
Tpt. 1 (B♭) 2
Tbn. 1
Tbn. 2
Timp.
Perc.
Bass Drum
Solo Tuba
9
Vln. I
Vln. II
Vla.
Vcl.
Db.
div.
unis.
unis.
pizz.
pizz.
pizz.

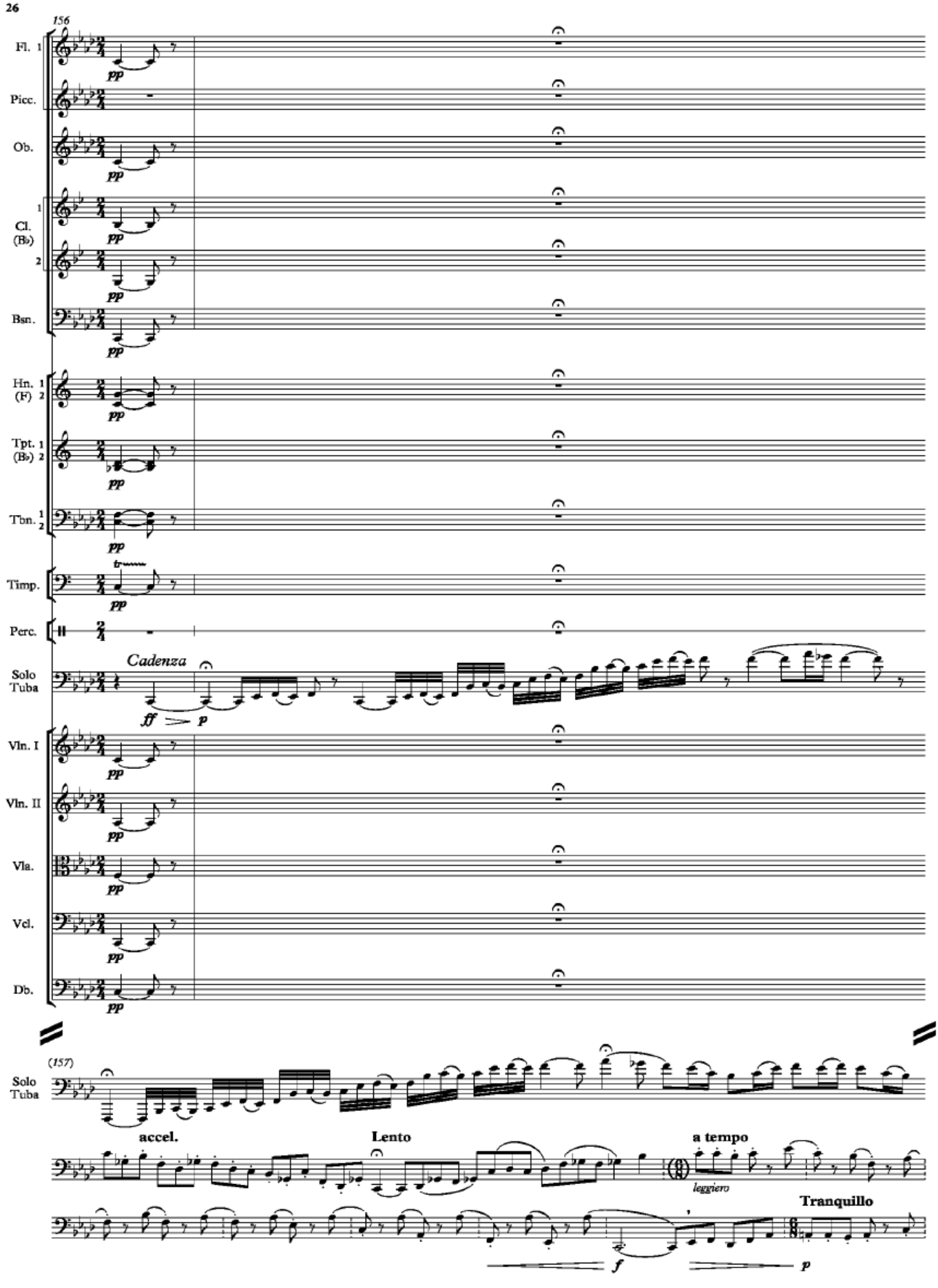

123
Fl.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Timp.
Perc.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
f
cresc.
arco

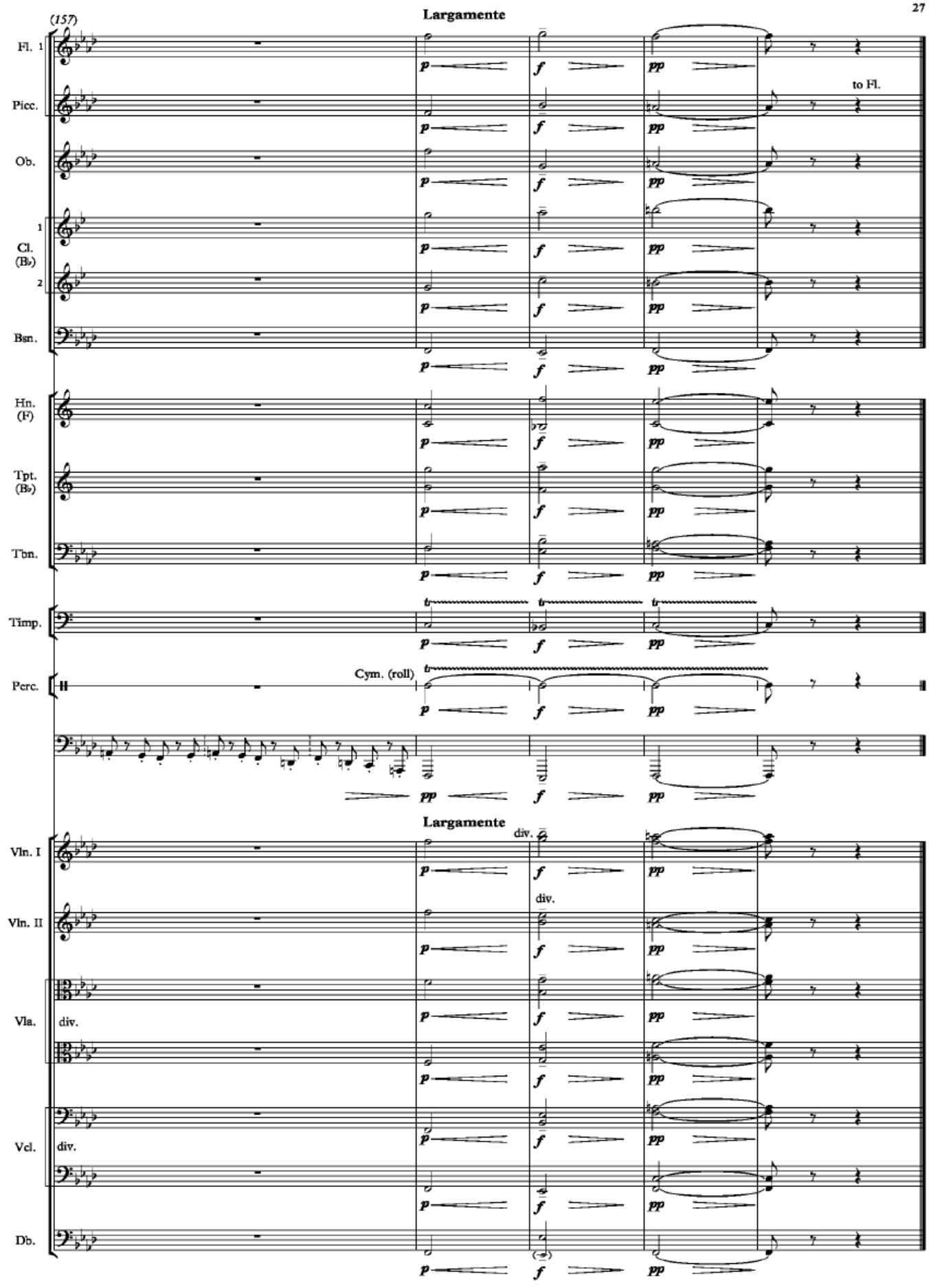

10
129
Fl.
to Picc.
Picc.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Timp.
Perc.
S.D.
Solo Tuba
lagato
f cantabile
10
Vln. I
Vln. II
Vla.
Vcl.
Db.


134
11
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
Cl. (B♭) 2
Bsn.
Hn. (F) 1
Hn. (F) 2
Tpt. (B♭) 1
Tpt. (B♭) 2
Tbn. 1
Tbn. 2
Timp.
Perc.
Solo Tuba
11
Vln. I
Vln. II
Vla.
Vcl.
Db.
non div.

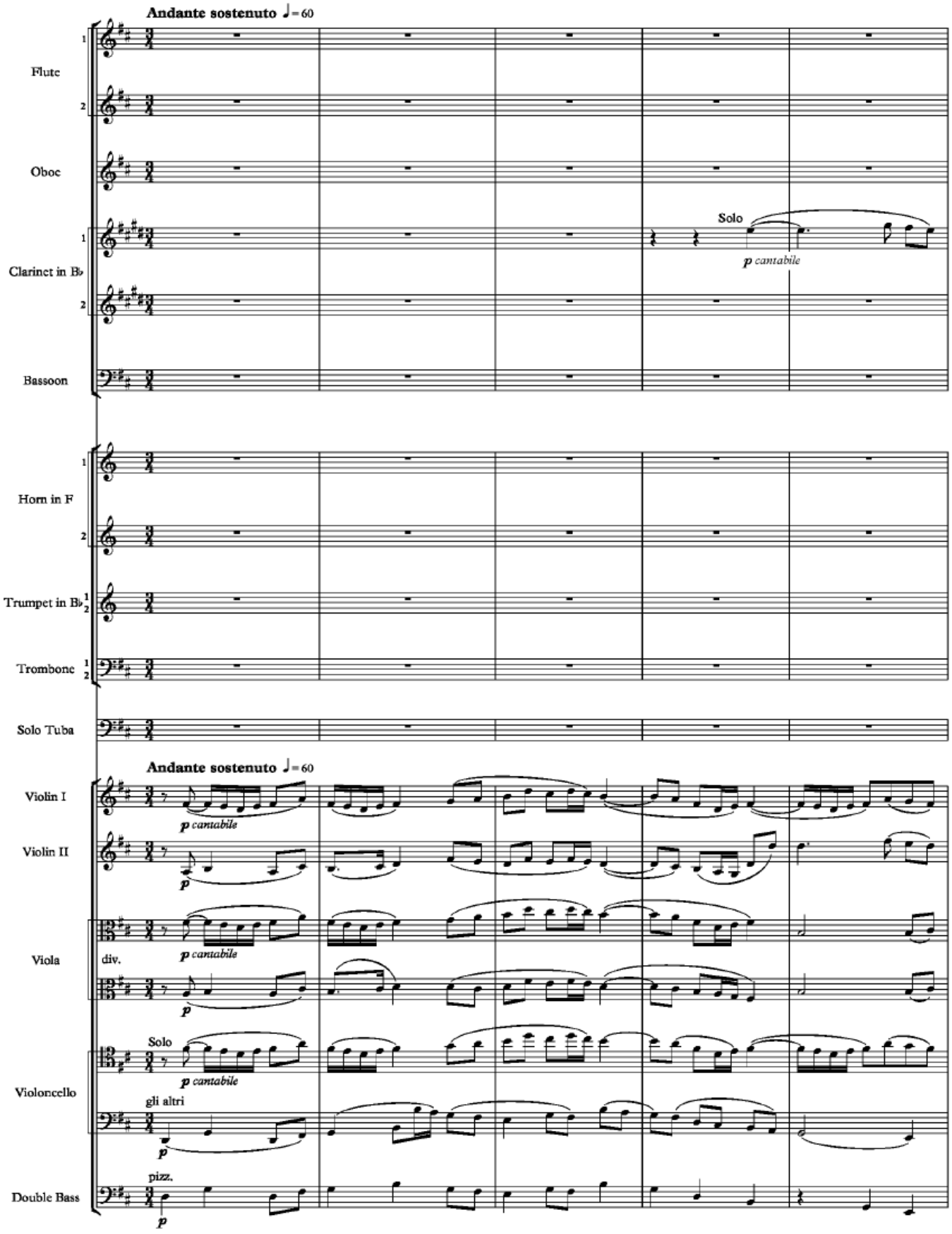

142
Fl. 1
Picc.
Ob.
1
Cl. (B♭)
2
Bsn.
1
Hn. (F)
2
1
Tpt. (B♭)
2
1
Tbn.
2
Timp.
Perc.
Cym. (nat.)
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
f
ff
cresc.

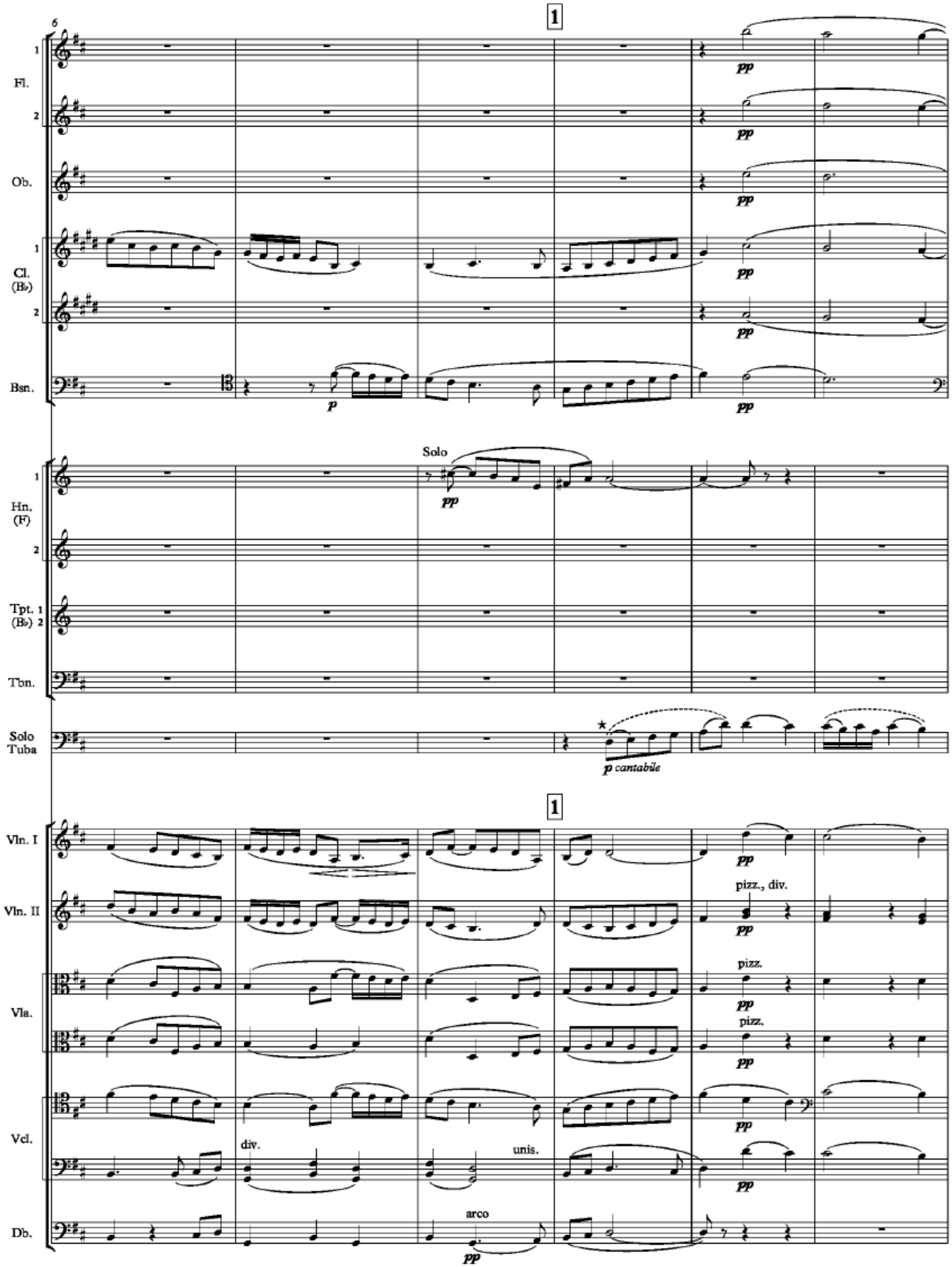

149
12
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1
2
Tbn. 1
2
Timp.
Perc.
Solo Tuba
12
Vln. I
Vln. II
Vla.
Vcl.
Db.
dim.
p
f
tr
2/4


156
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1 2
Tpt. (B♭) 1 2
Tbn. 1 2
Timp.
Perc.
Solo Tuba
Cadenza
Vln. I
Vln. II
Vla.
Vcl.
Db.
(157)
accel.
Lento
a tempo
leggiero
Tranquillo

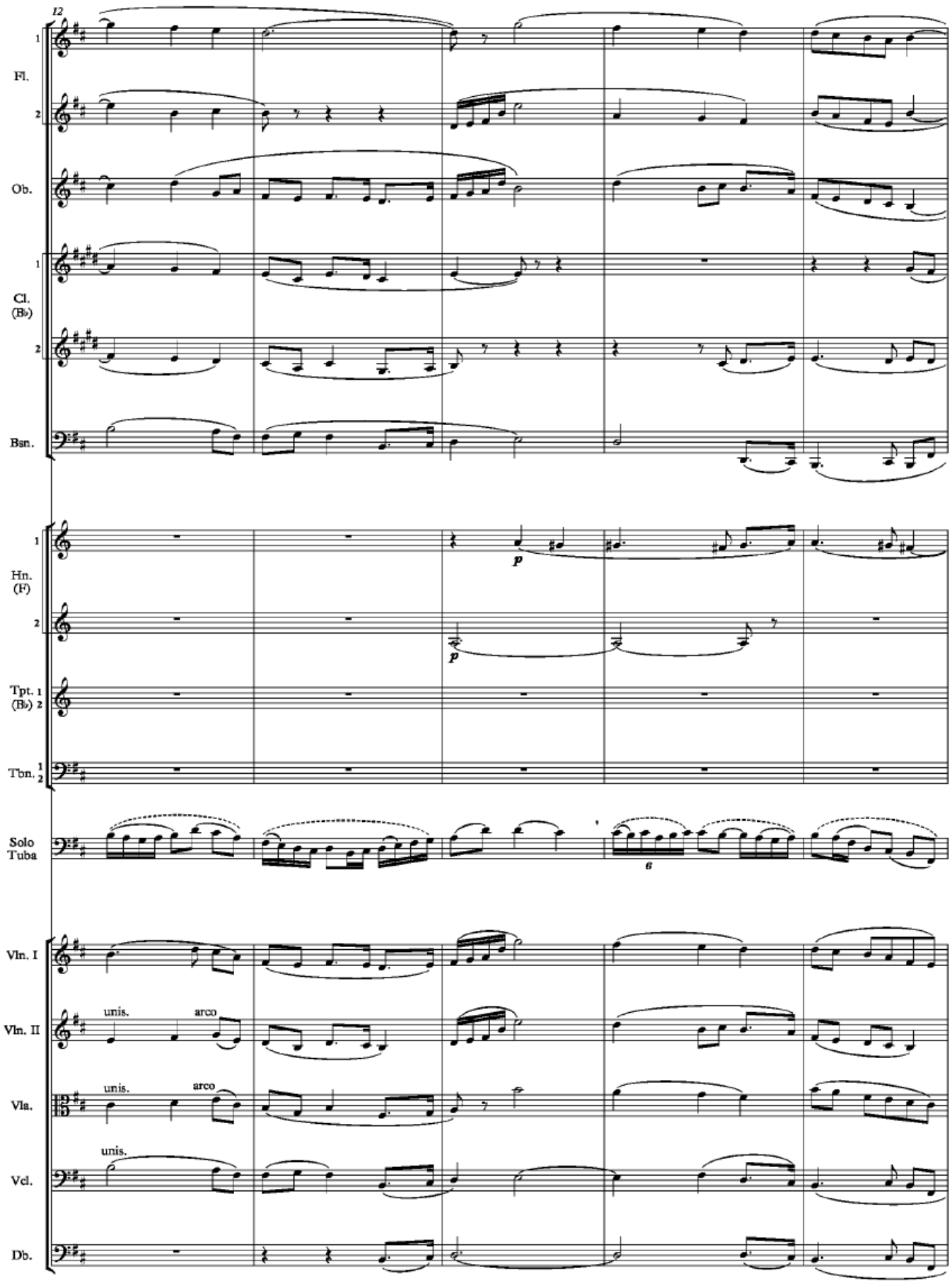

(157)
Largamente
Fl. 1
Picc.
to Fl.
Ob.
1
Cl. (B♭)
2
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Timp.
Perc.
Cym. (roll)
Largamente
Vln. I
div.
Vln. II
div.
Vla.
div.
Vcl.
div.
Db.
p
f
pp

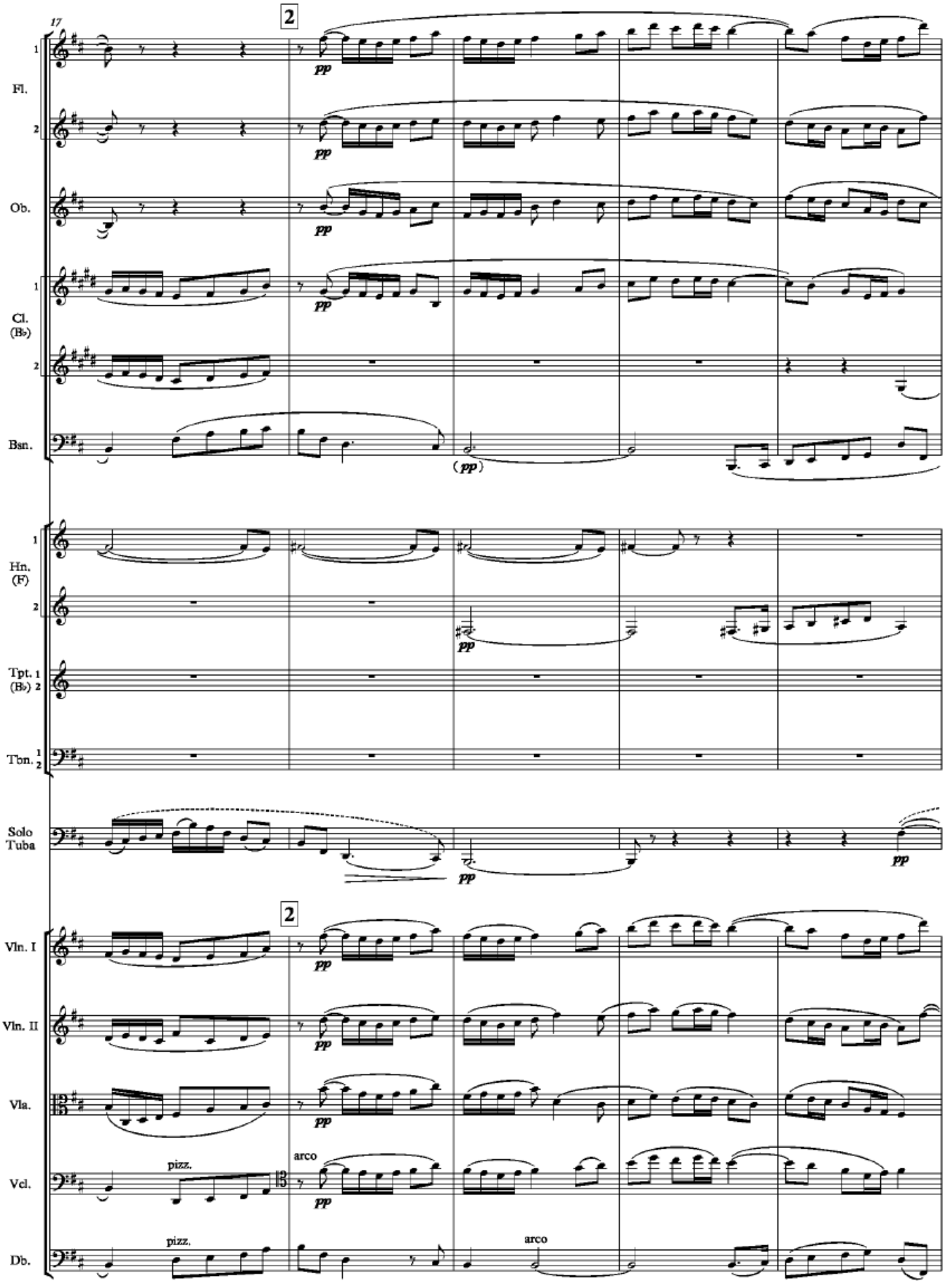
II. Romanza

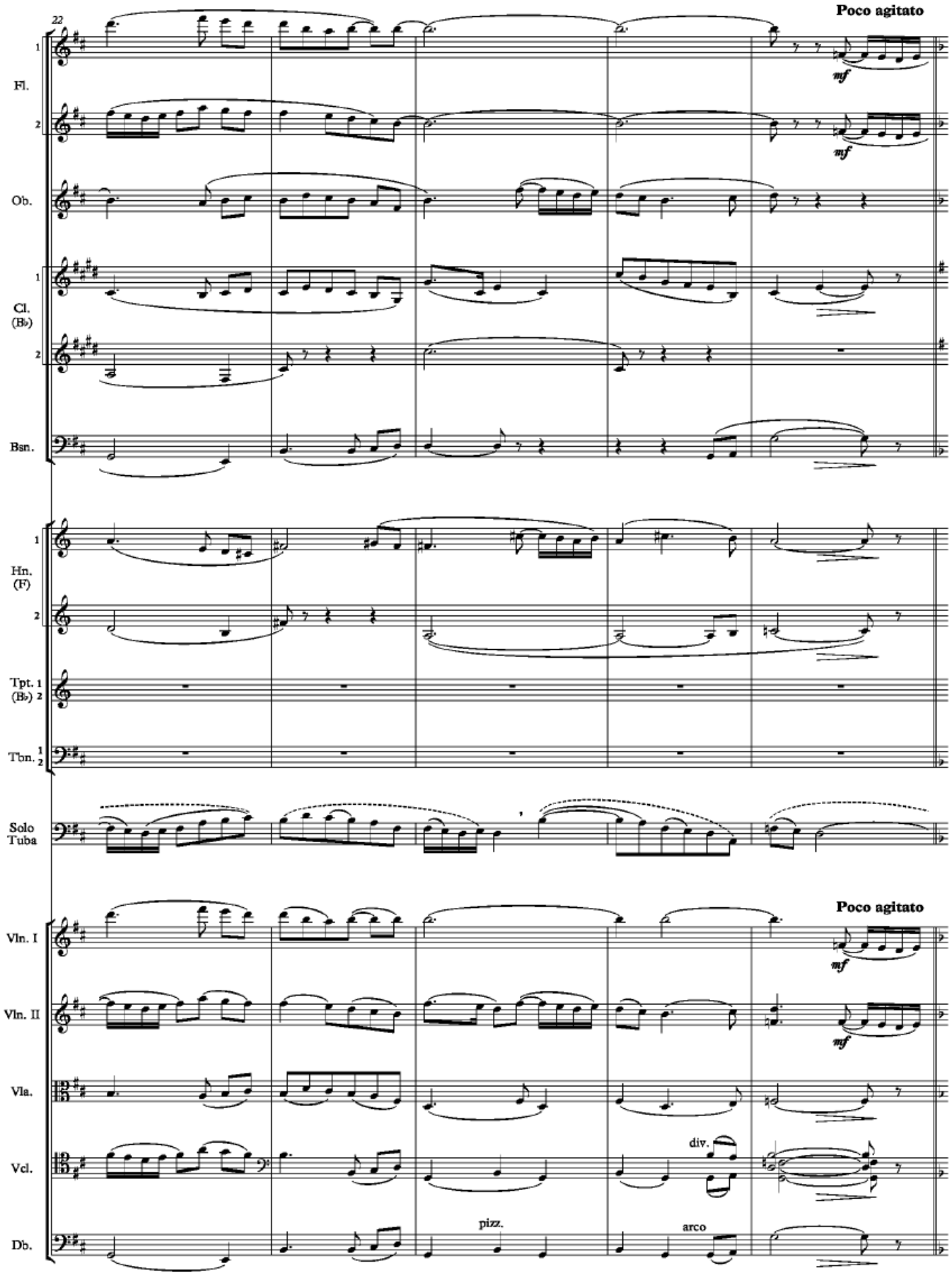

Andante sostenuto ♩= 60
Flute
Oboe
Clarinet in B♭
Bassoon
Solo
p cantabile
Horn in F
Trumpet in B♭
Trombone
Solo Tuba
Andante sostenuto ♩= 60
Violin I
Violin II
Viola
Violoncello
Double Bass
p cantabile
div.
Solo
gli altri
pizz.

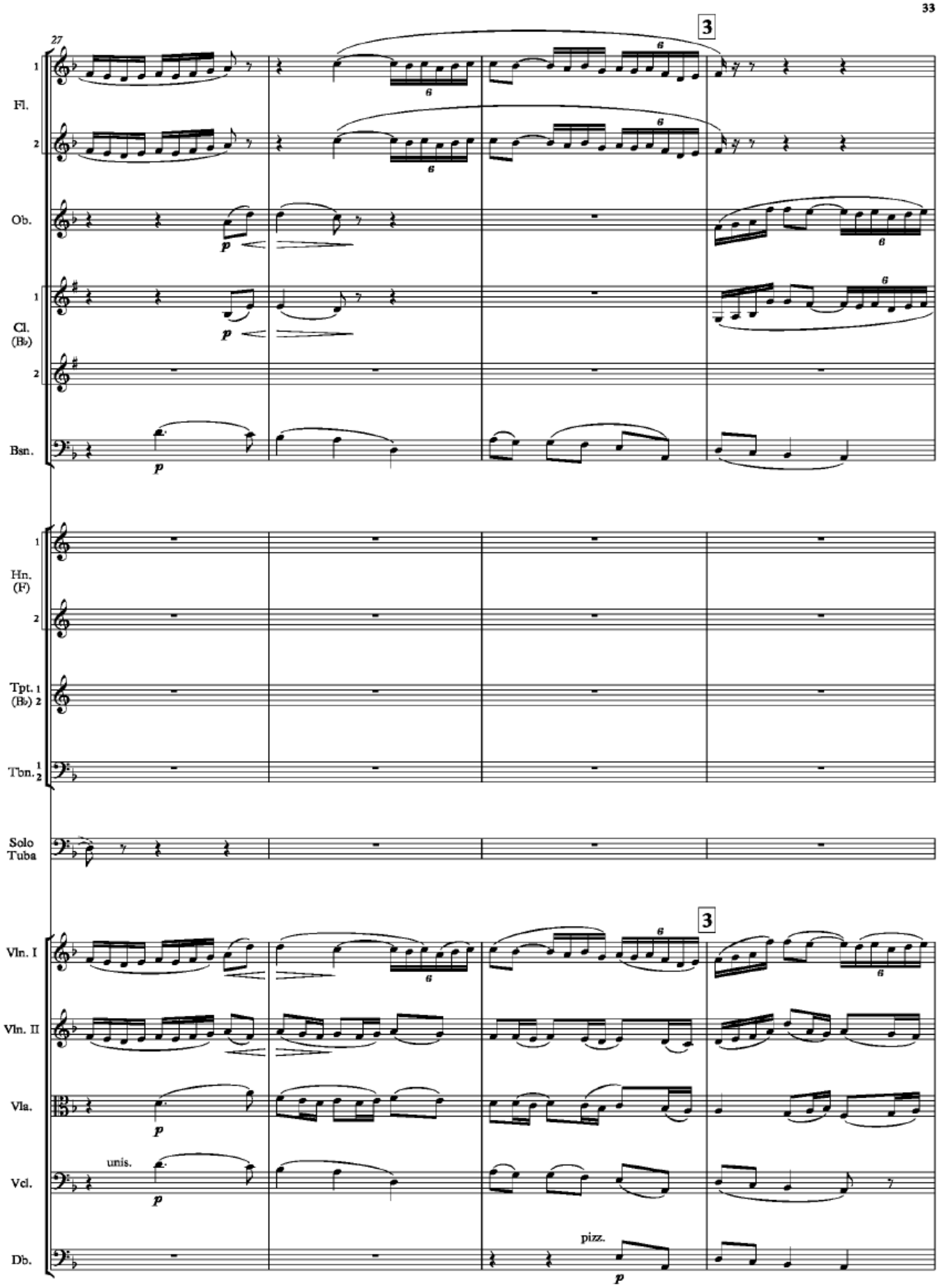


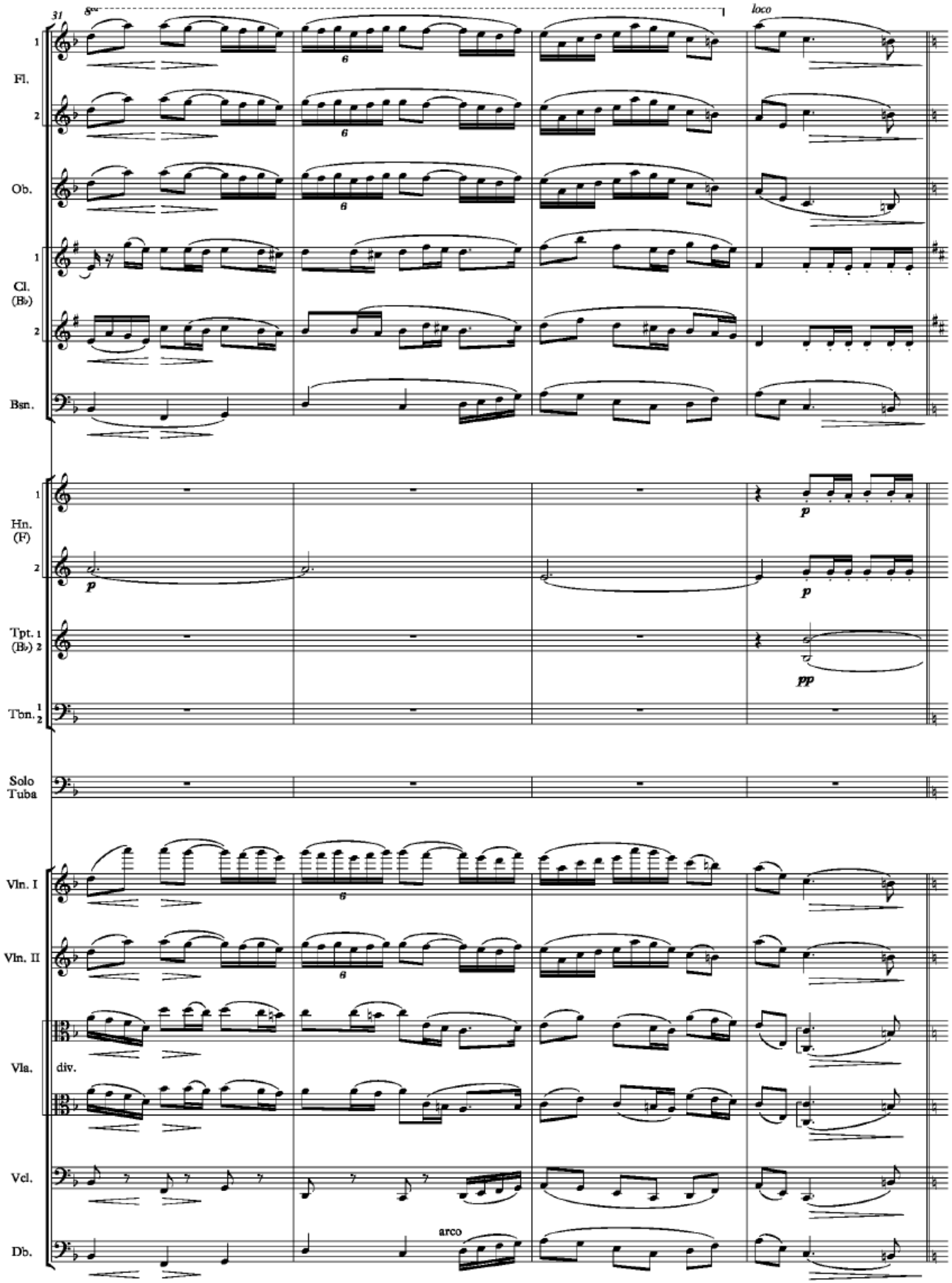
*In this movement the slurs printed in normal style are as originally *published*; the dotted slurs are as originally *written*. See p. iv.

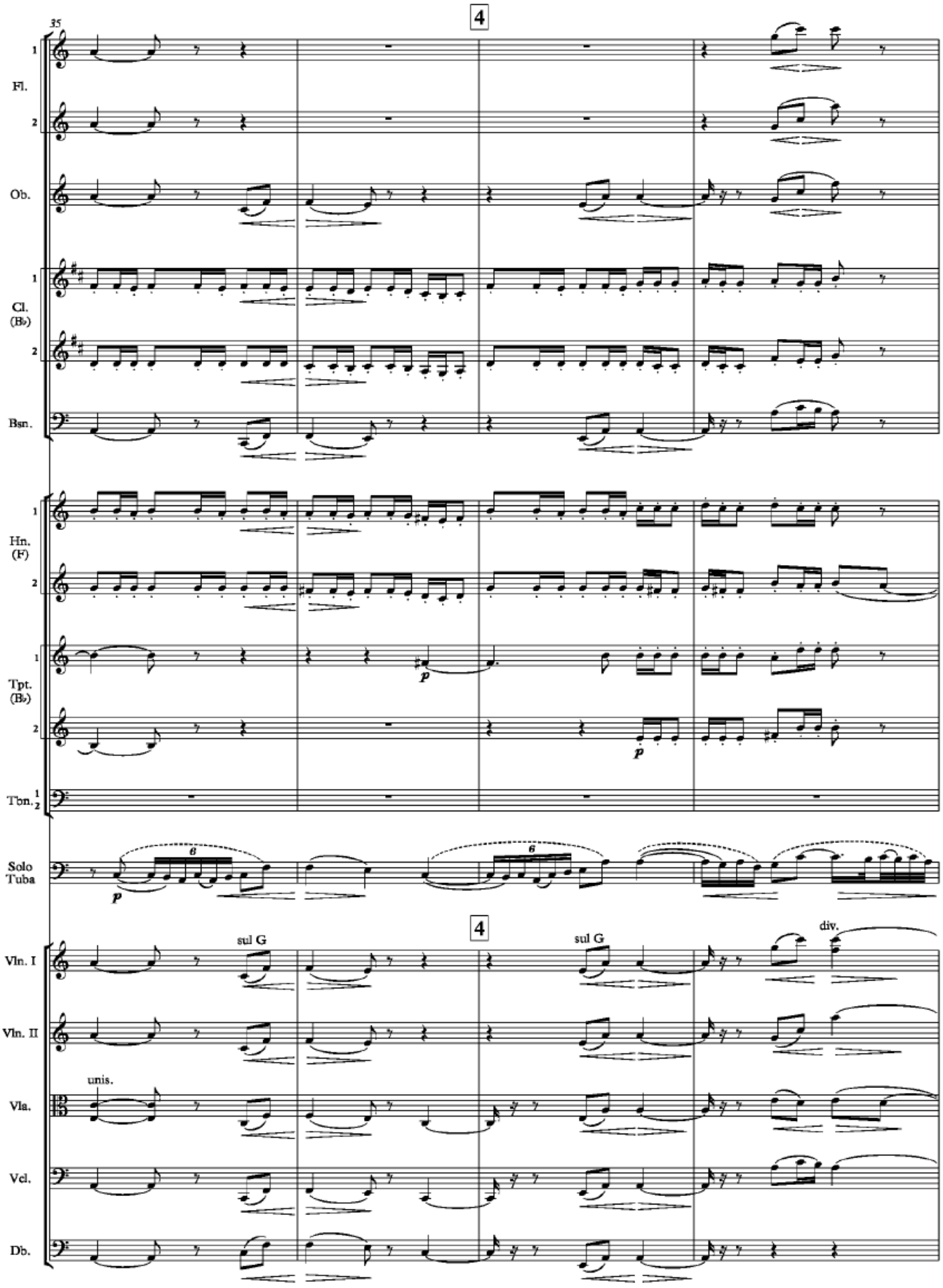

12
Fl.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
p
unis.
arco
unis.
arco
unis.

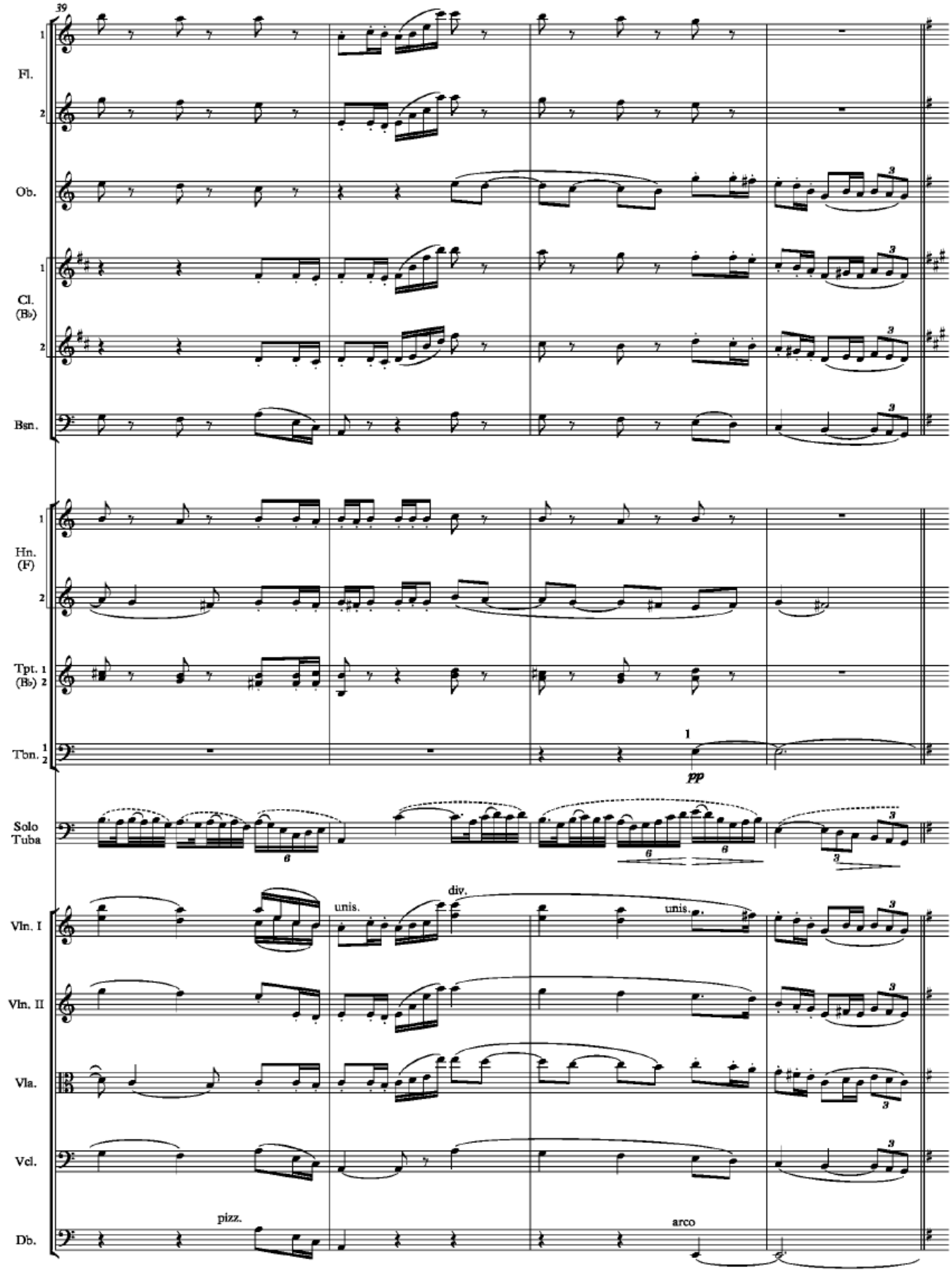

17
2
Fl.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
pp
(pp)
pizz.
arco

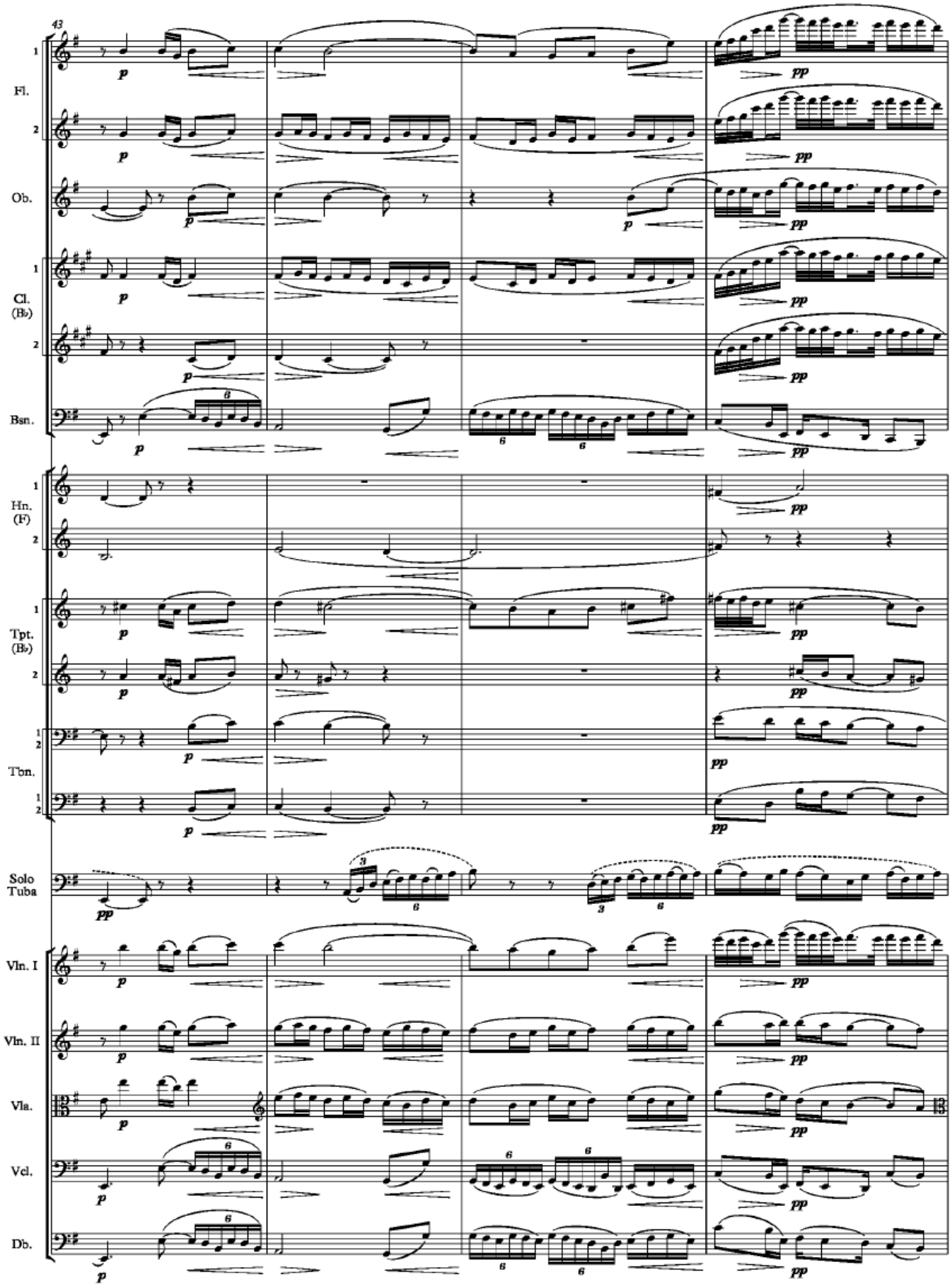

22
Poco agitato
Fl.
1
2
Ob.
Cl. (B♭)
1
2
Bsn.
Hn. (F)
1
2
Tpt. 1 (B♭) 2
Tbn. 1 2
Solo Tuba
Poco agitato
Vln. I
Vln. II
Vla.
Vcl.
Db.
mf
mf
div.
pizz.
arco

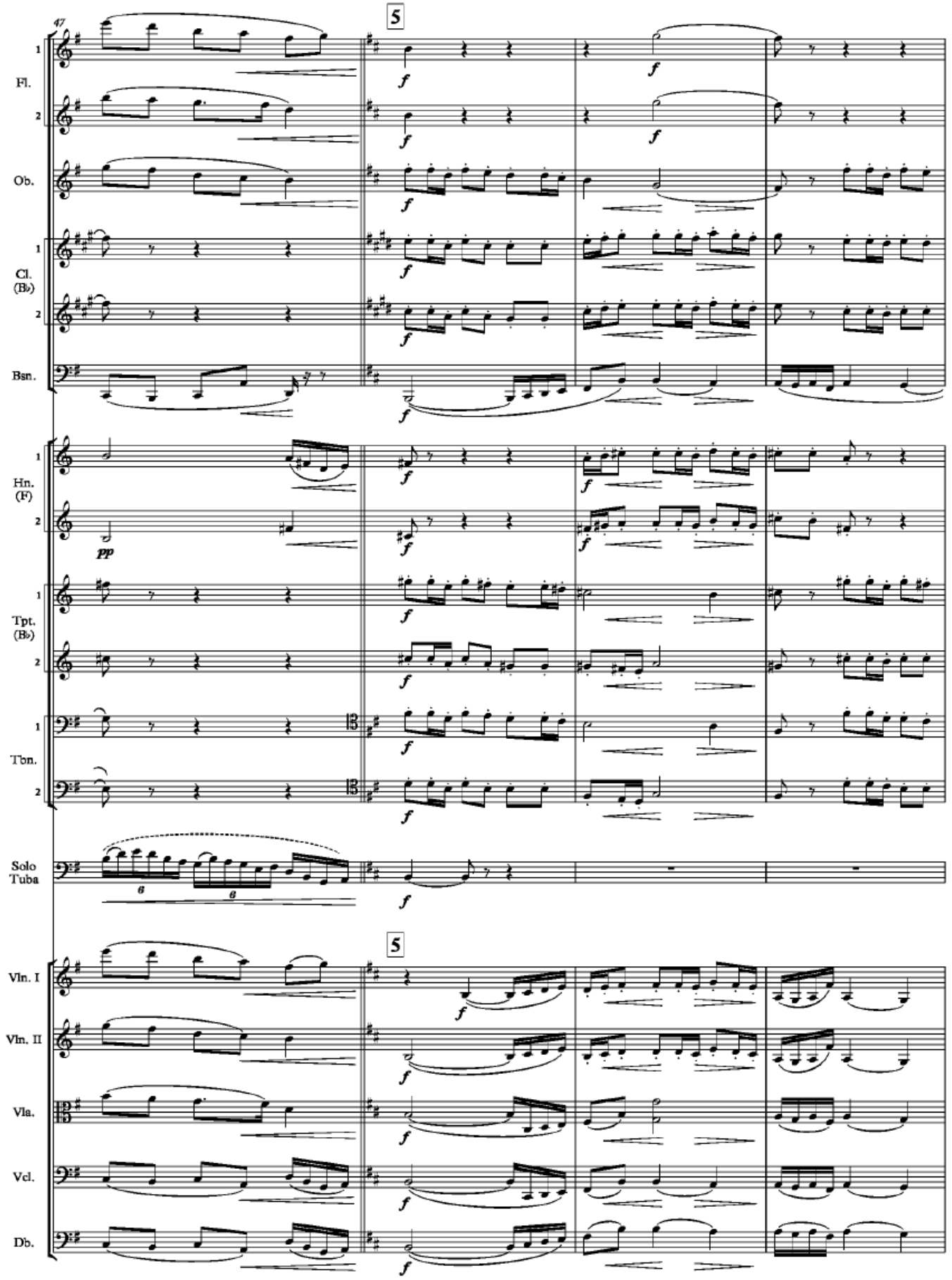

27
3
Fl. 1
Fl. 2
Ob.
Cl. (B♭) 1
Cl. (B♭) 2
Bsn.
Hn. (F) 1
Hn. (F) 2
Tpt. (B♭) 1 2
Tbn. 1 2
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
unis.
pizz.
p

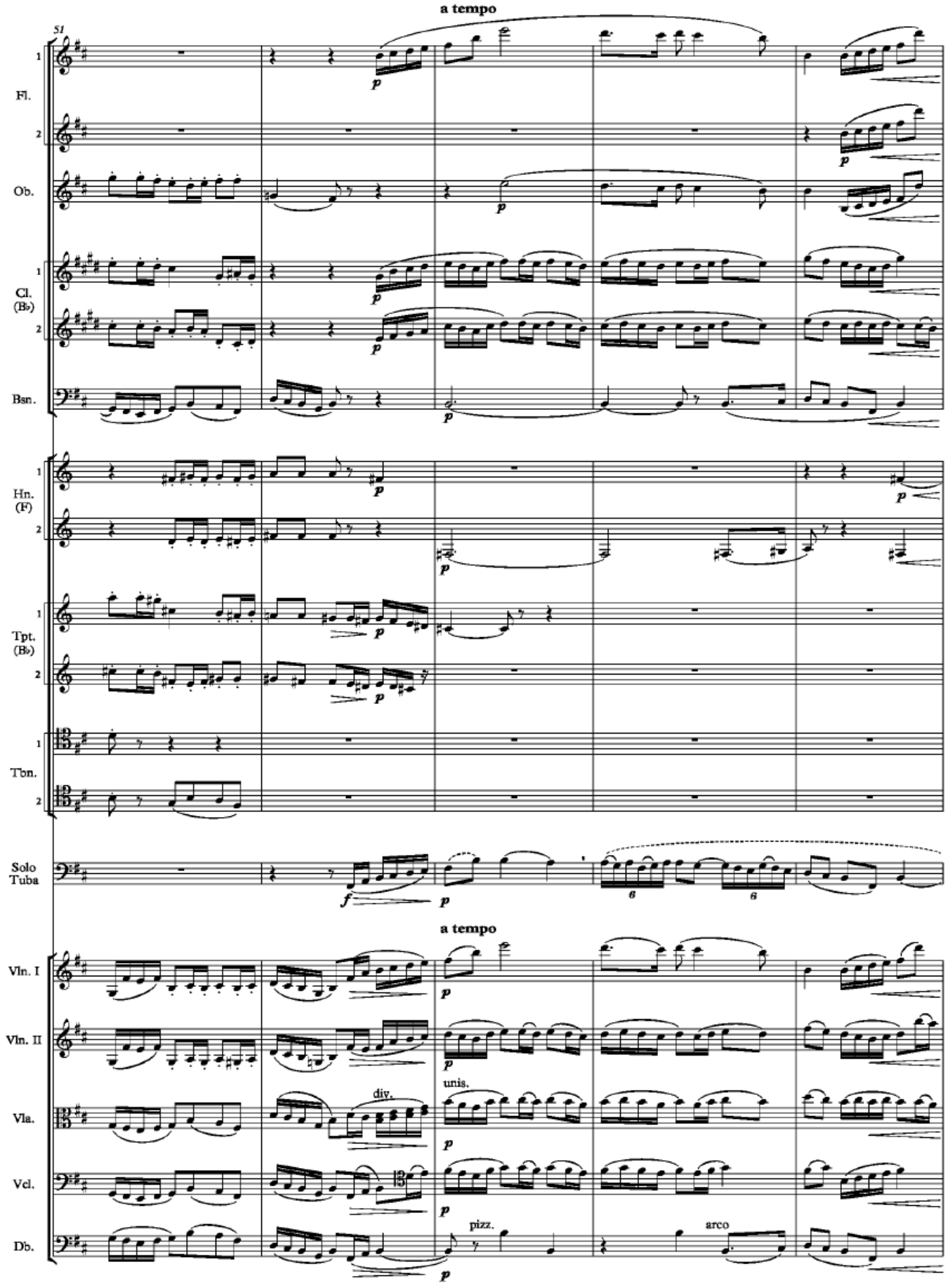

31
8va
loco
Fl.
1
2
Ob.
Cl. (B♭)
1
2
Bsn.
Hn. (F)
1
2
p
Tpt. 1 2 (B♭)
pp
Tbn. 1 2
Solo Tuba
Vln. I
Vln. II
Vla.
div.
Vcl.
Db.
arco

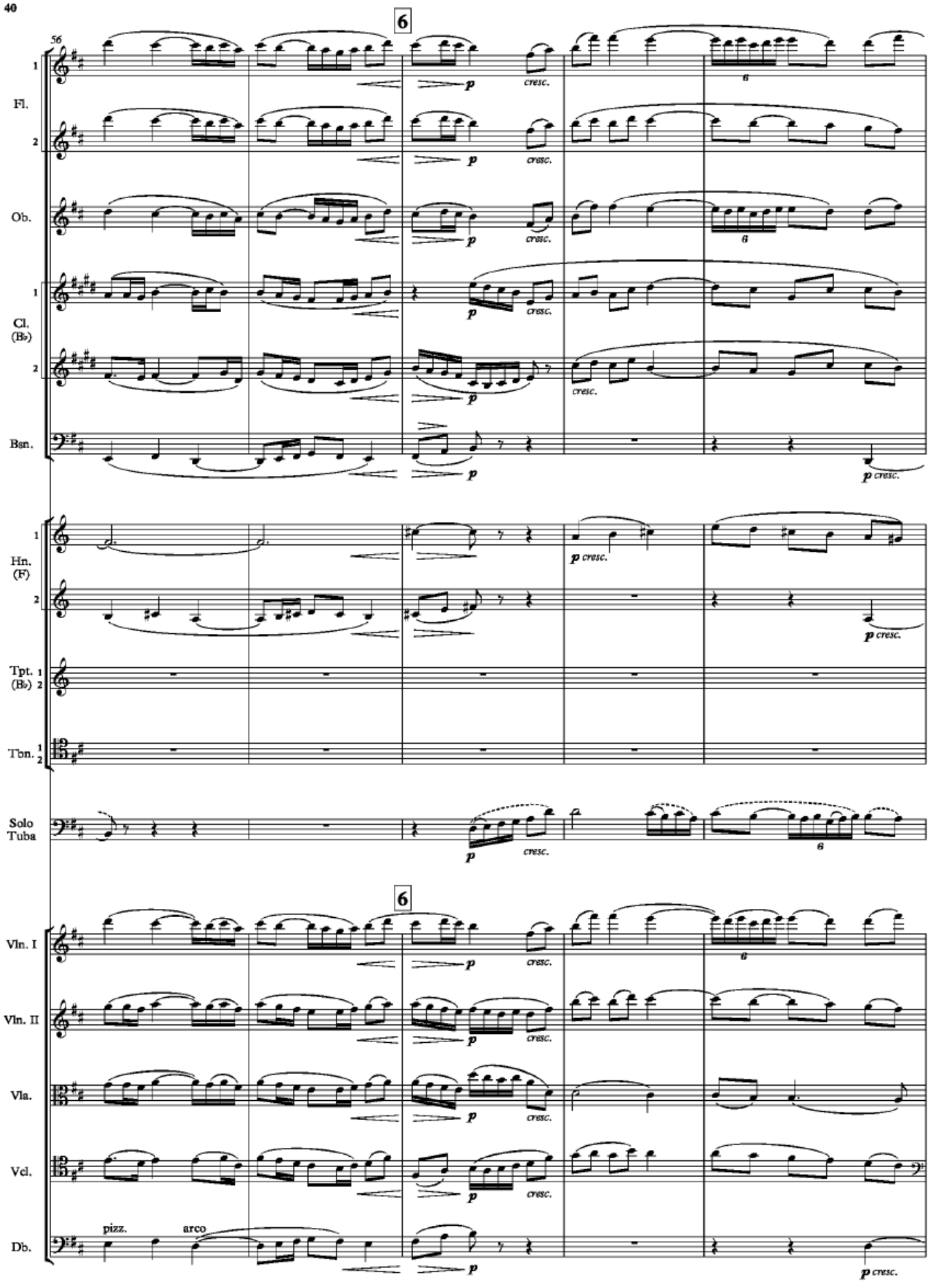

35
4
Fl.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Solo Tuba
4
sul G
sul G
div.
Vln. I
Vln. II
unis.
Vla.
Vcl.
Db.

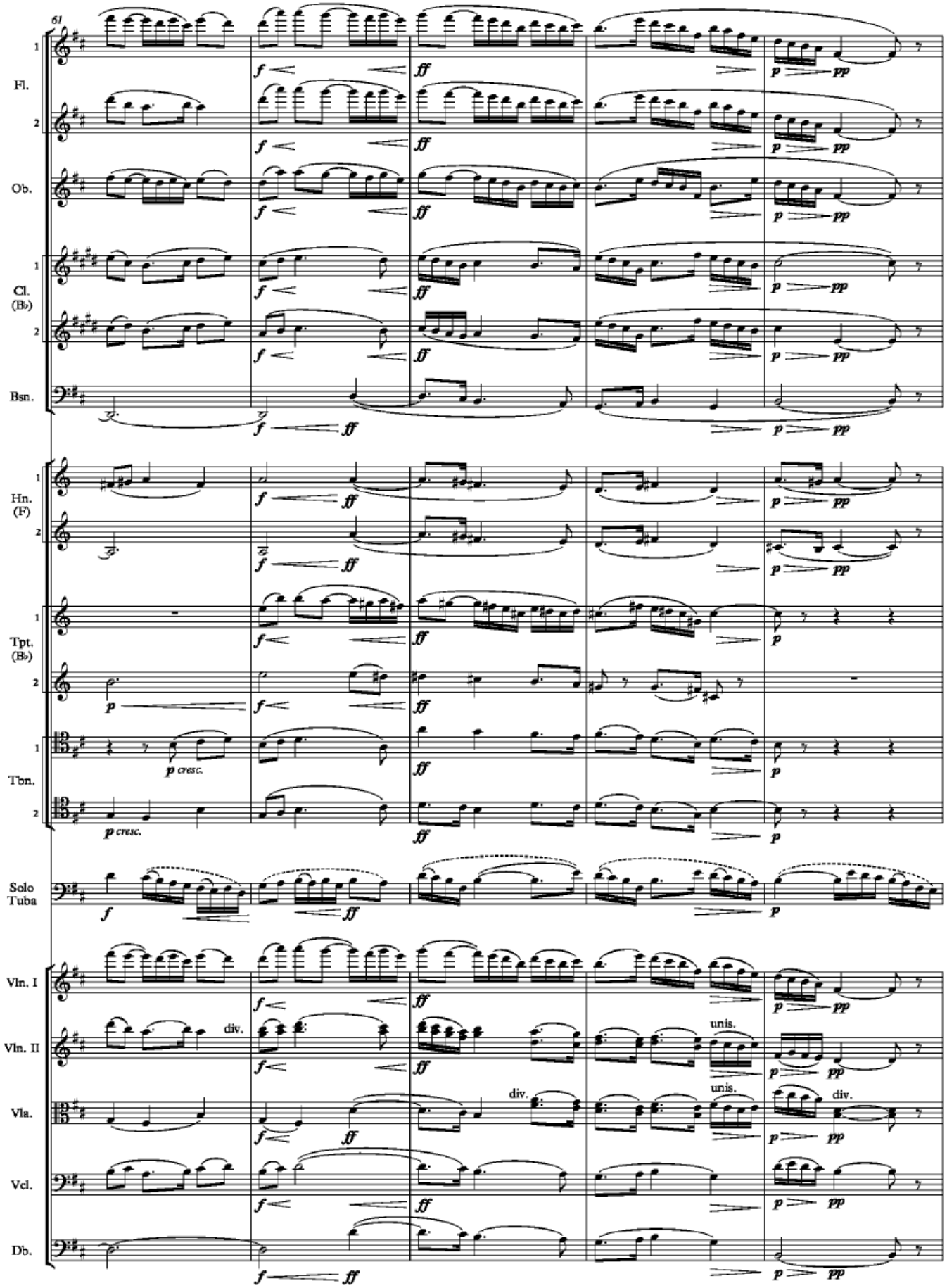

39
Fl.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
pp
unis.
div.
unis.
pizz.
arco

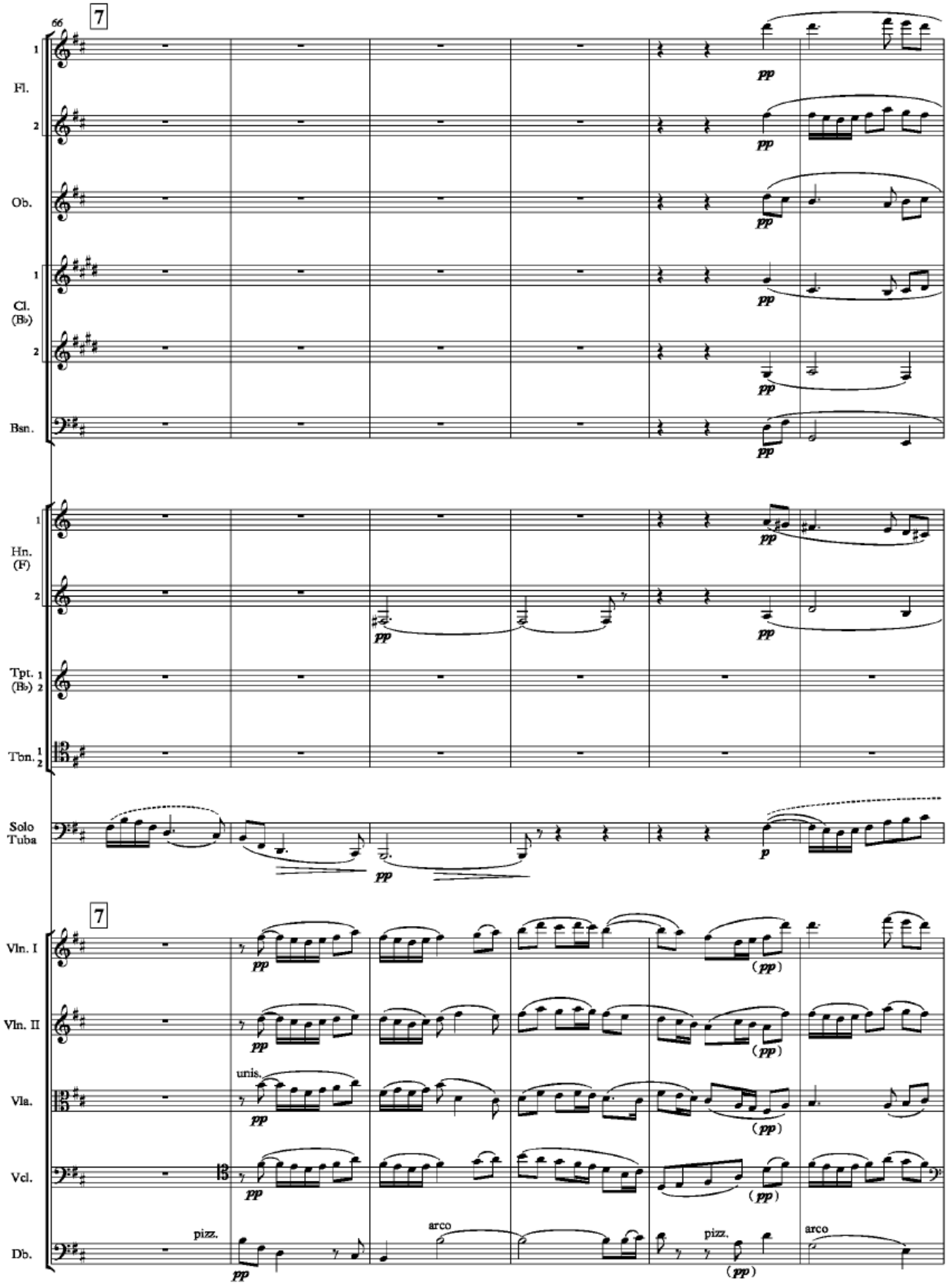

43
Fl.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
p
pp

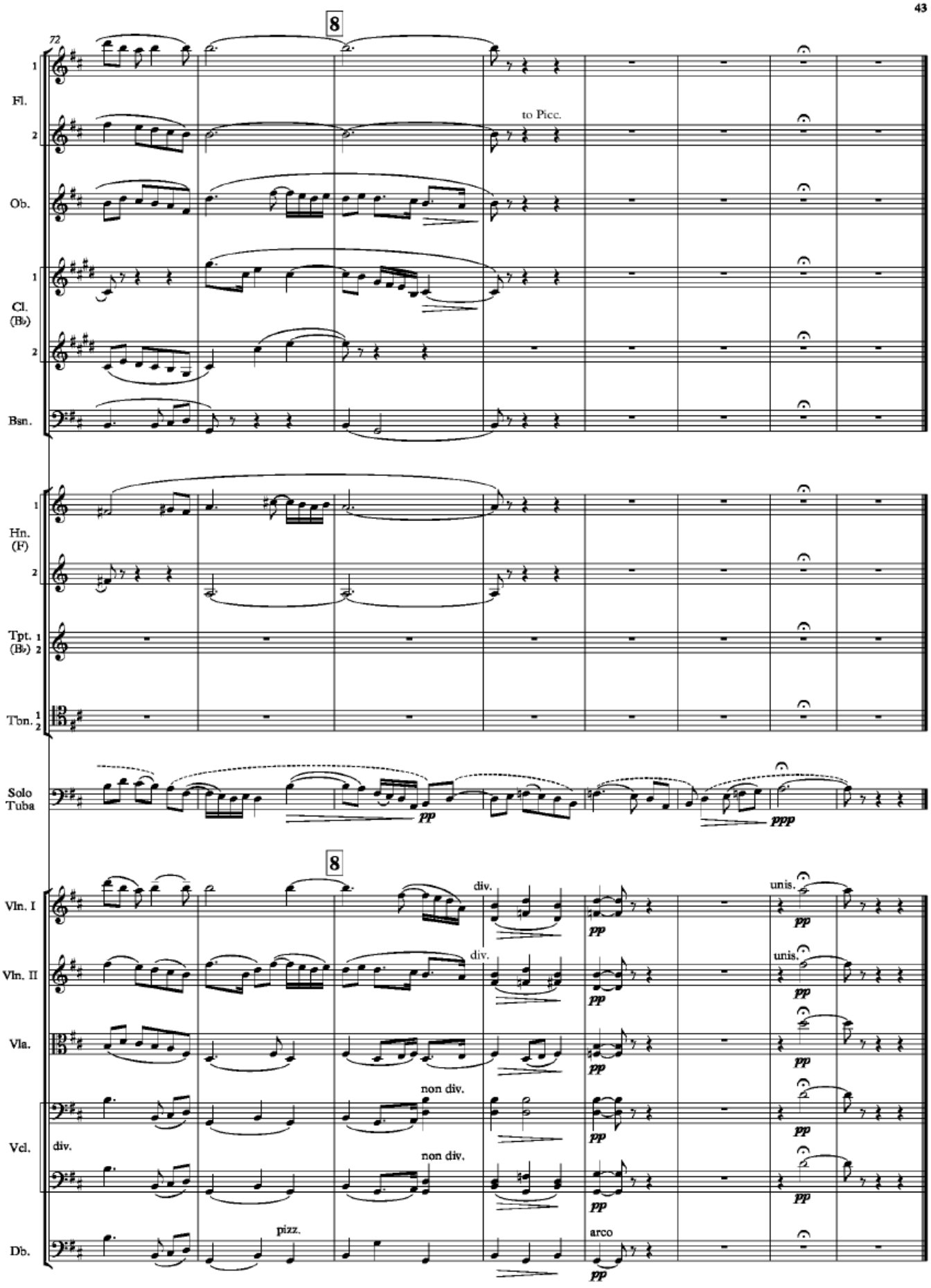

47
5
Fl.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
f
pp


a tempo
51
Fl.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Solo Tuba
a tempo
Vln. I
Vln. II
Vla.
Vcl.
Db.
div.
unis.
pizz.
arco

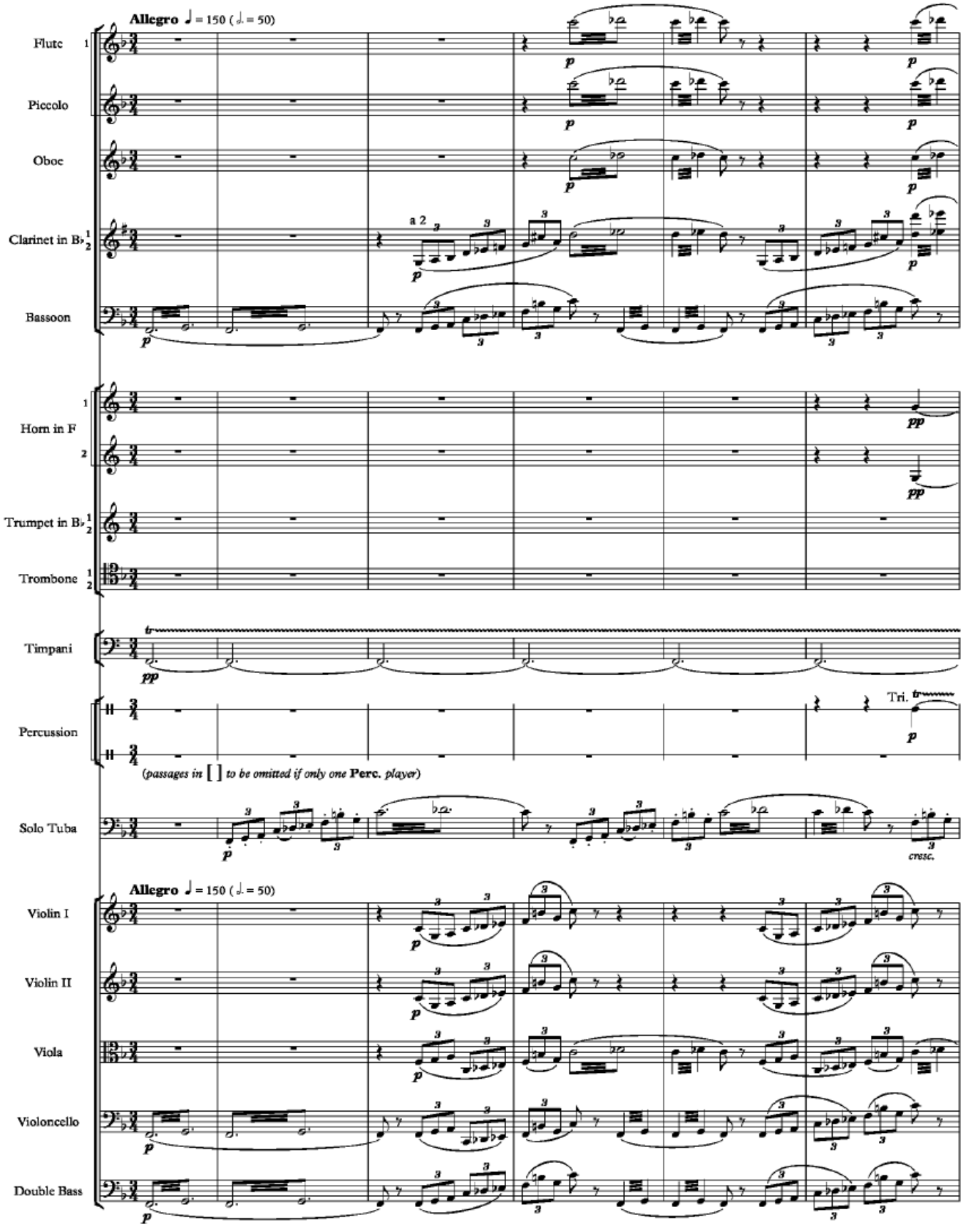

56
6
Fl.
1
2
Ob.
Cl. (B♭)
1
2
Bsn.
Hn. (F)
1
2
Tpt. (B♭)
1 2
Tbn.
1 2
Solo Tuba
6
Vln. I
Vln. II
Vla.
Vcl.
Db.
pizz.
arco
p
cresc.
p cresc.

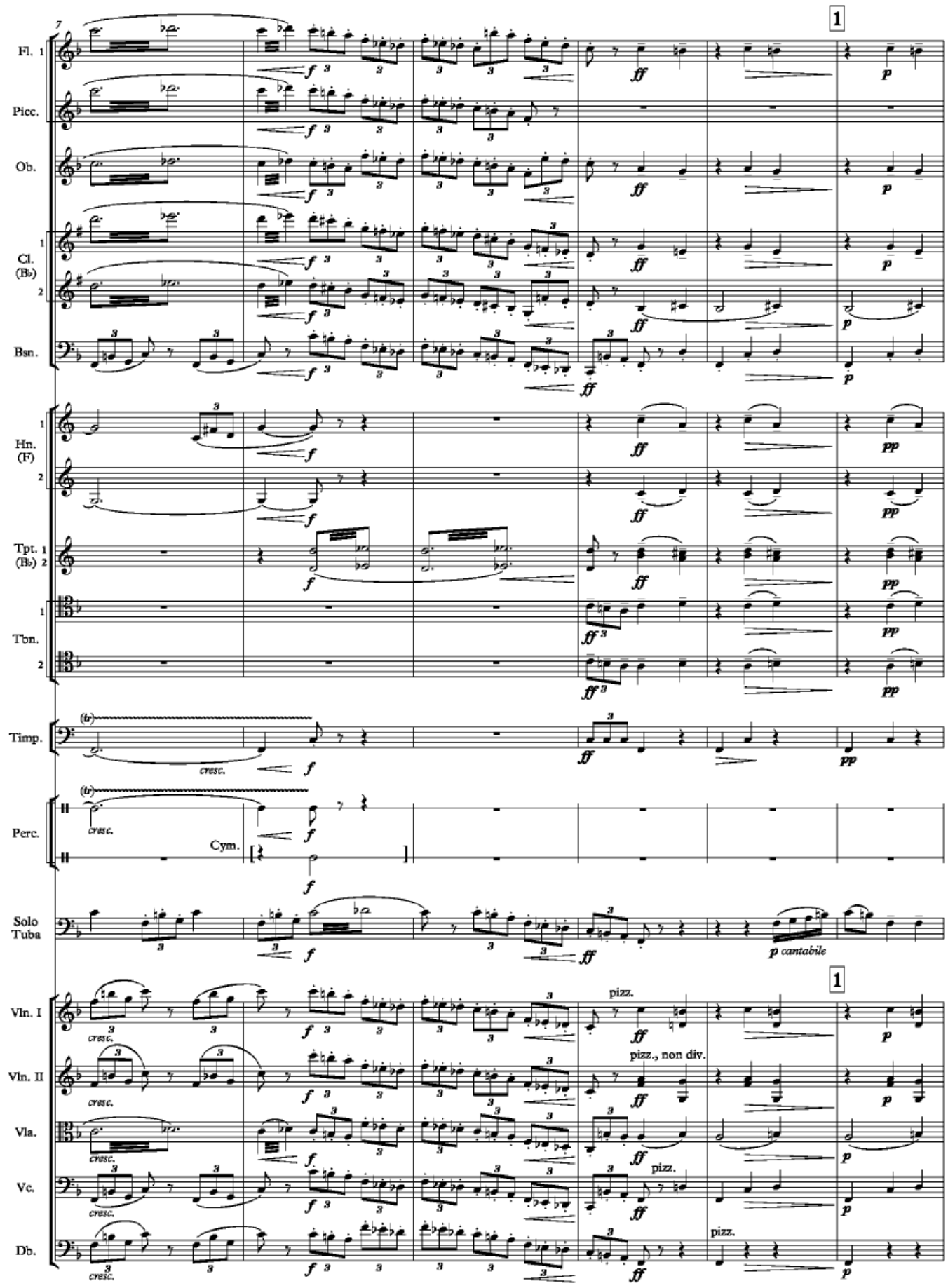

61
Fl.
Ob.
Cl. (B♭)
Bsn.
Hn. (F)
Tpt. (B♭)
Tbn.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
f
ff
p
pp
p cresc.
div.
unis.

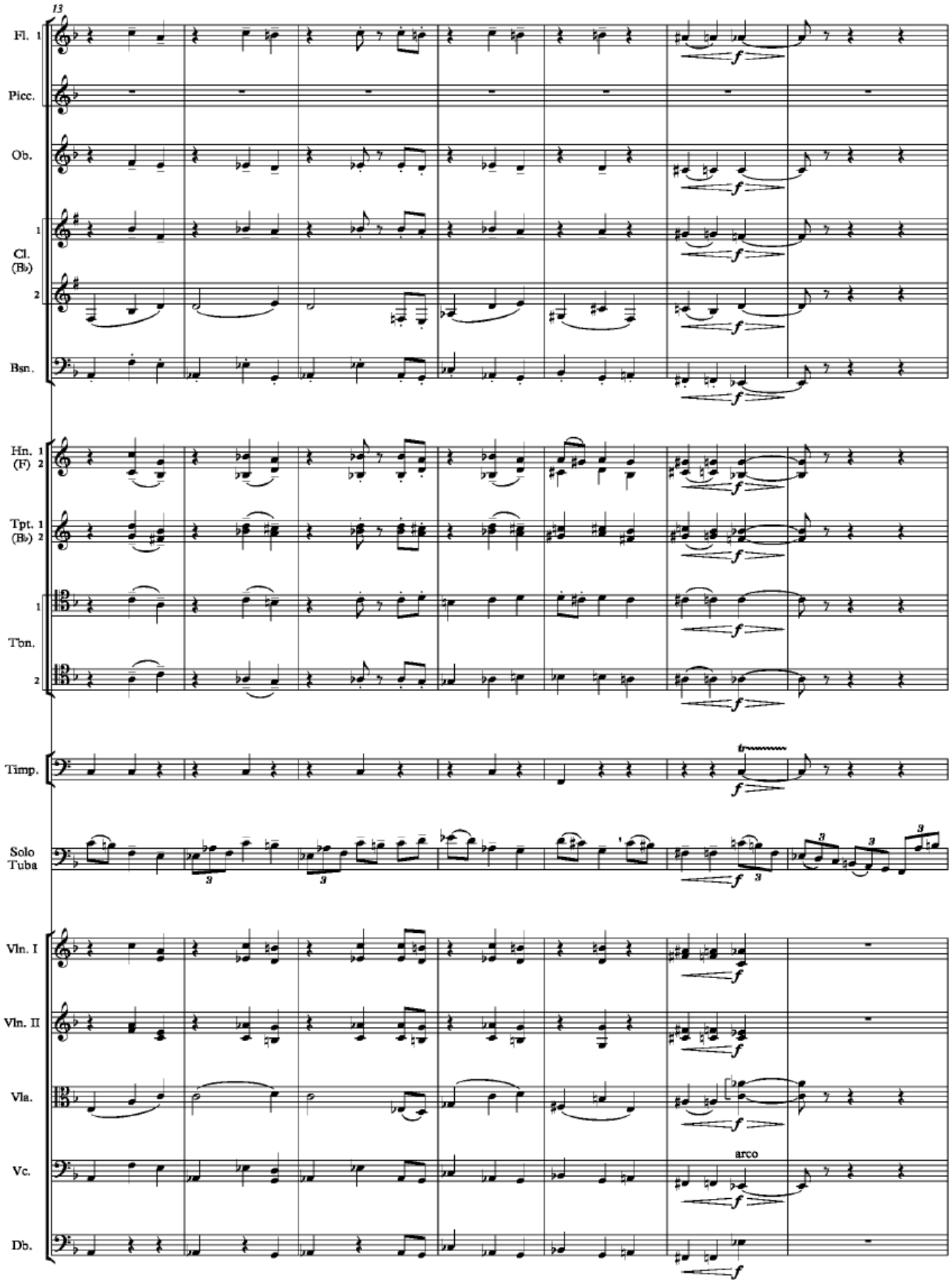

66
7
Fl.
Ob.
Cl. (Bb)
Bsn.
Hn. (F)
Tpt. (Bb)
Tbn.
Solo Tuba
Vln. I
Vln. II
Vla.
Vcl.
Db.
pp
p
unis.
pizz.
arco

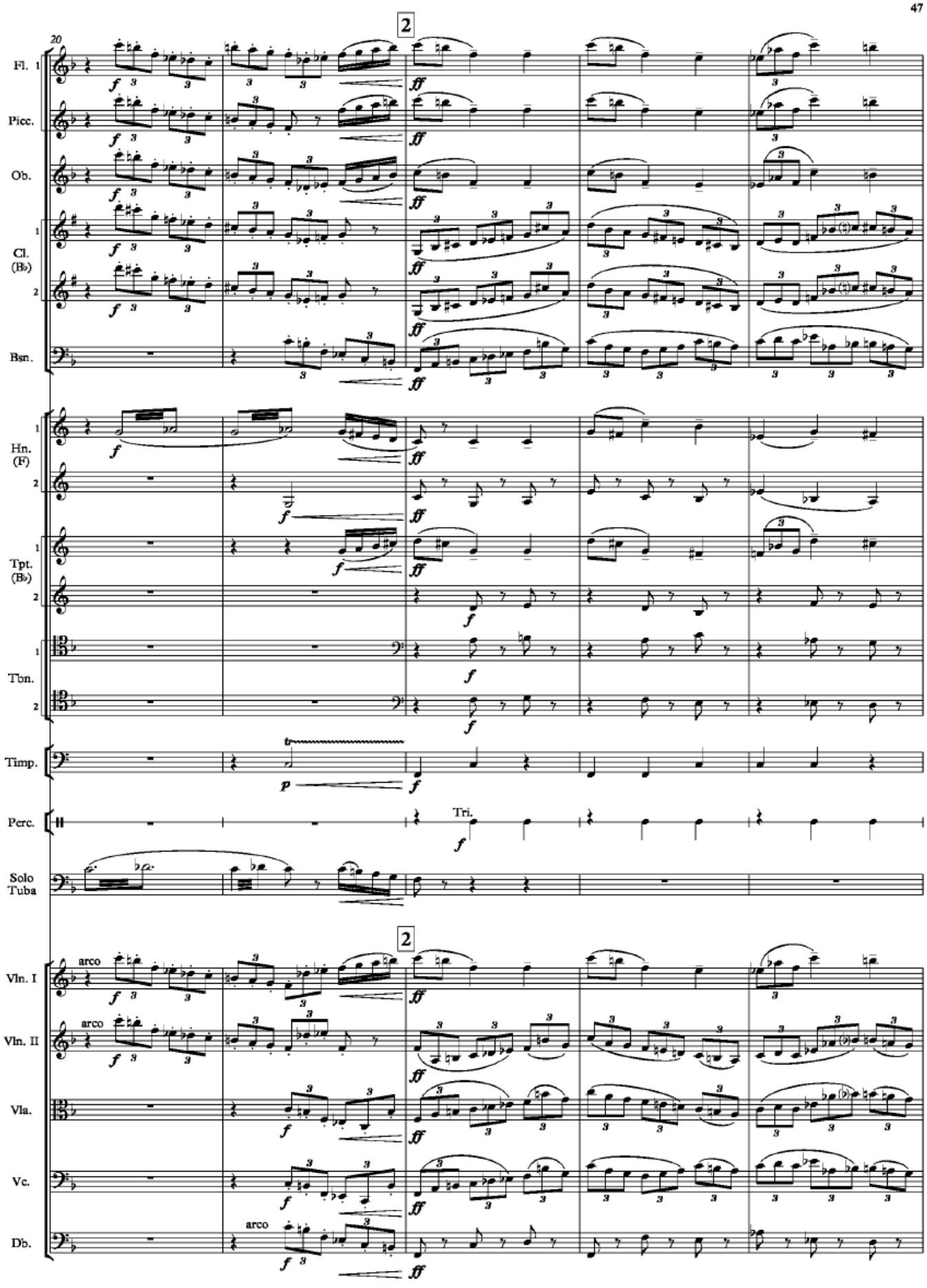

72
8
Fl.
1
2
to Picc.
Ob.
Cl. (B♭)
1
2
Bsn.
Hn. (F)
1
2
Tpt. (B♭) 1 2
Tbn. 1 2
Solo Tuba
pp
ppp
8
Vln. I
div.
unis.
pp
Vln. II
div.
unis.
pp
Vla.
pp
non div.
Vcl.
div.
non div.
pp
pizz.
Db.
arco
pp

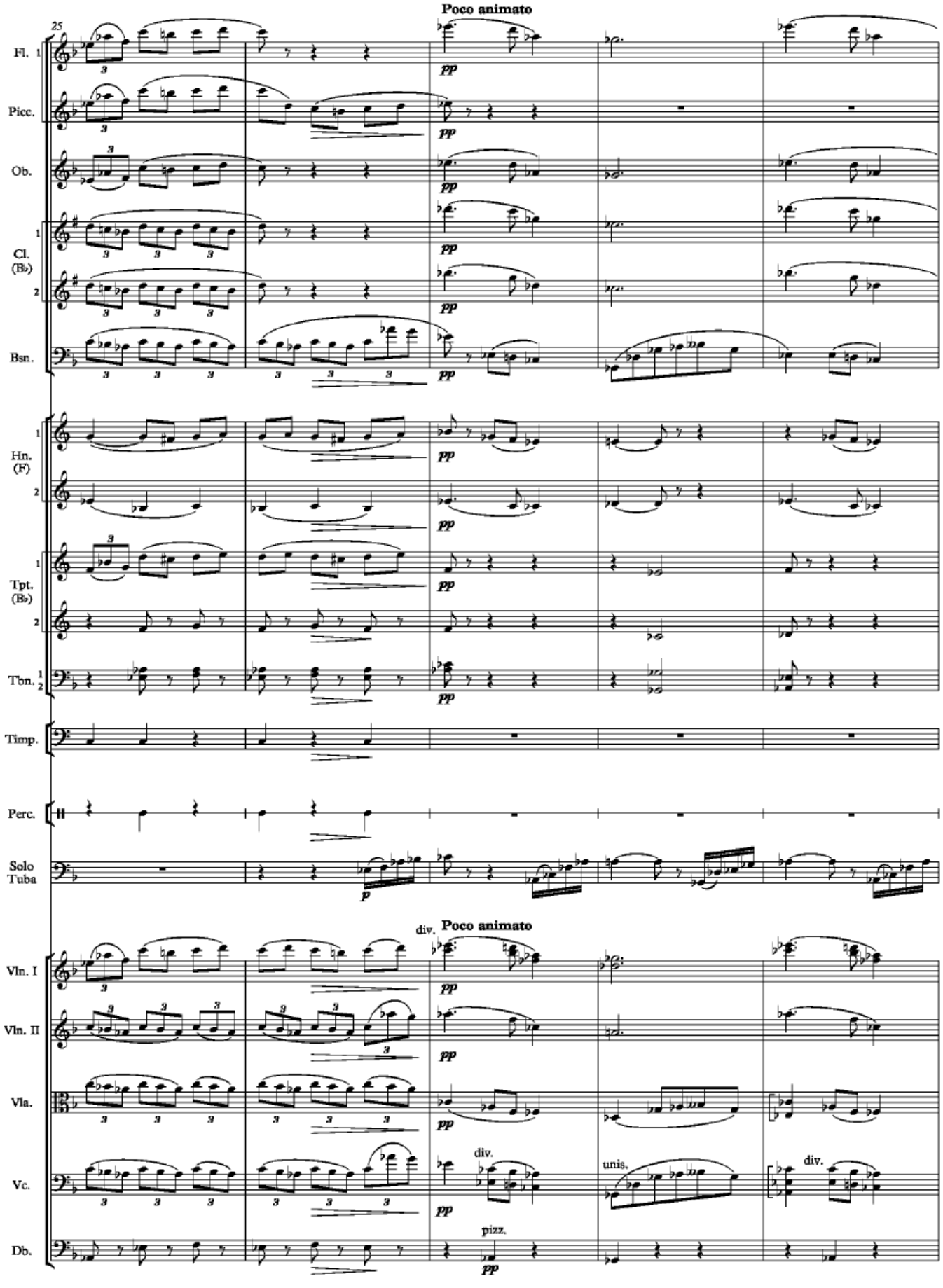
III. Finale — Rondo alla Tedesca

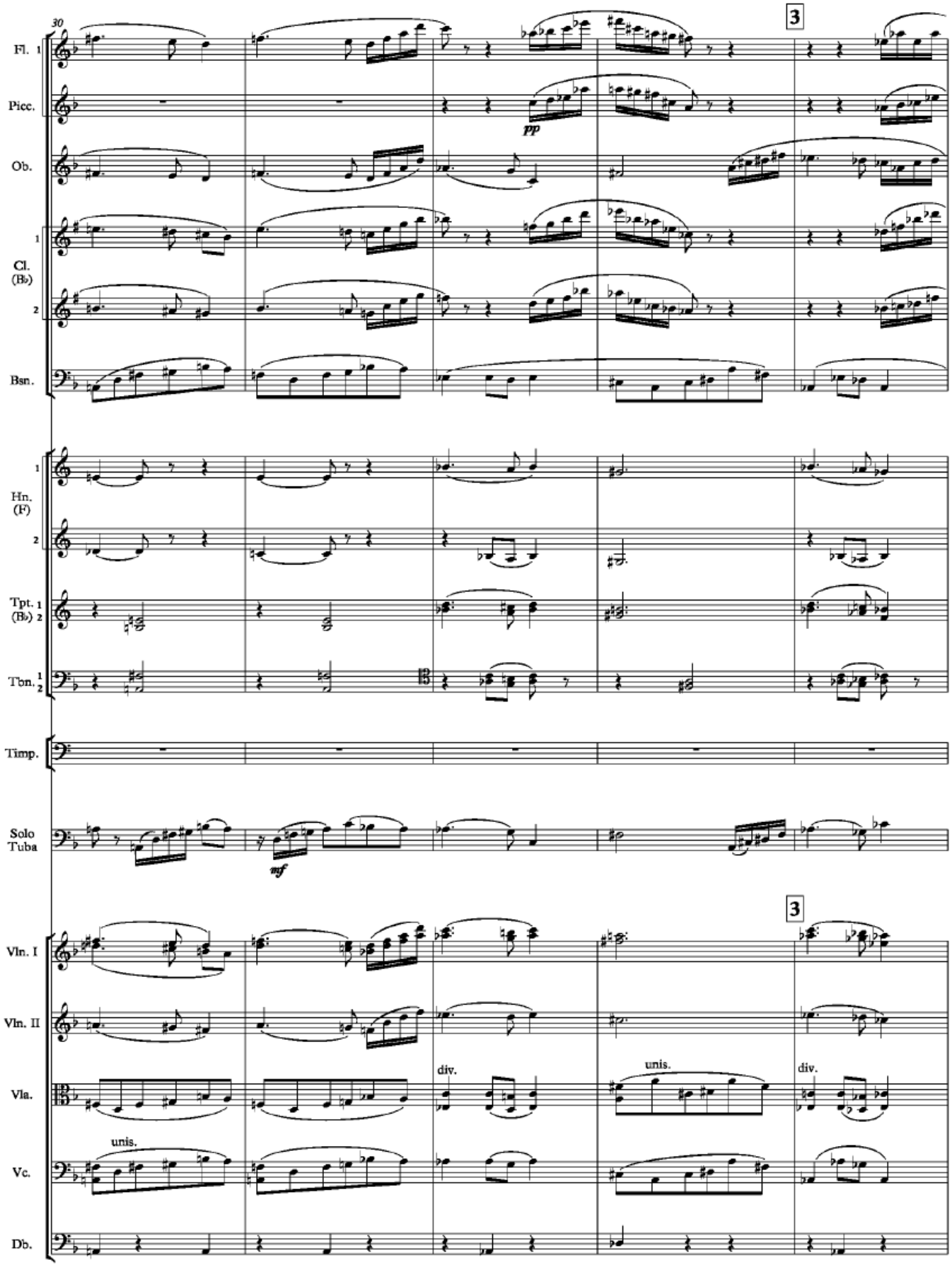


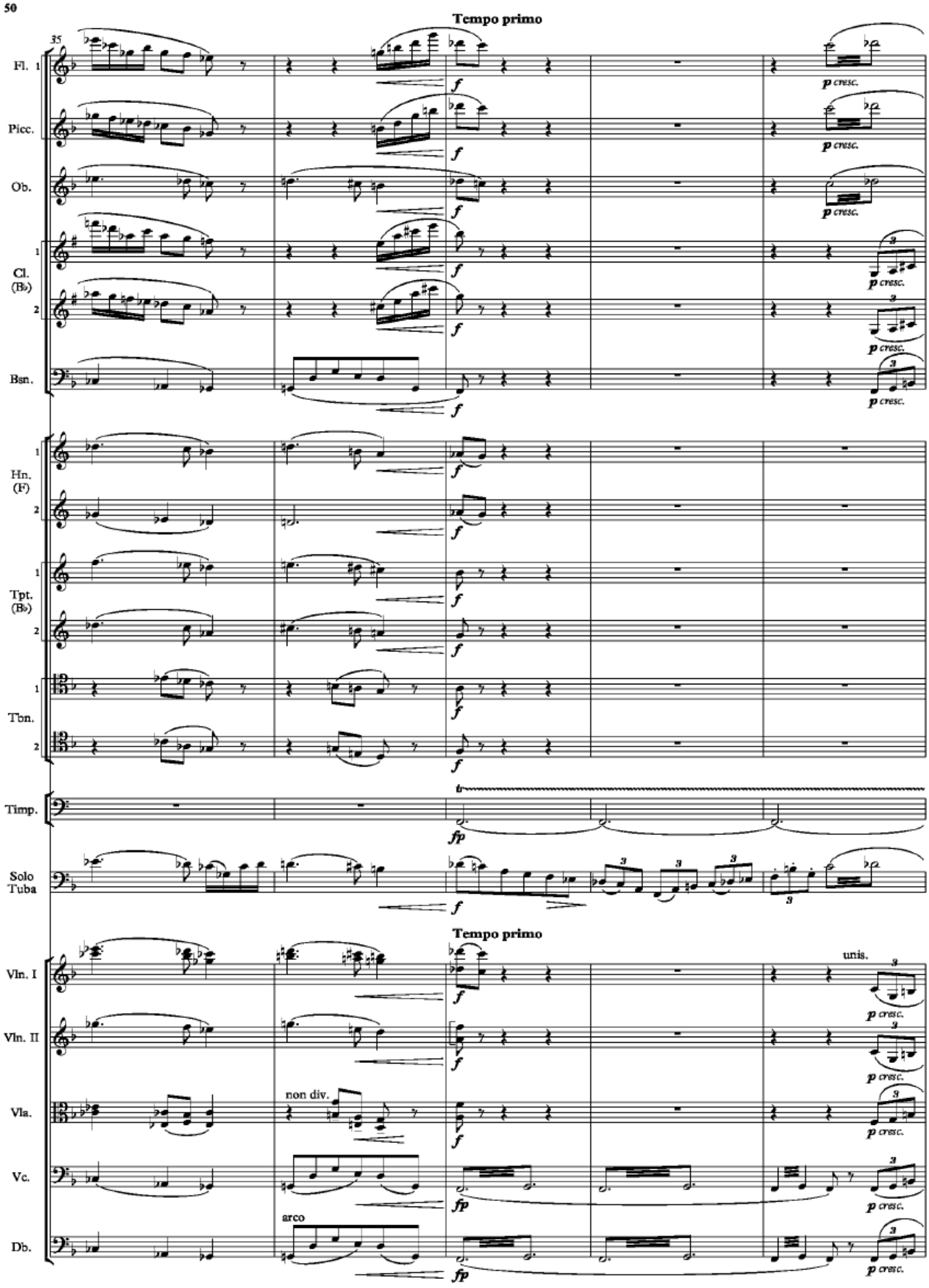

7
1
Fl. 1
Picc.
Ob.
Cl. (B♭) 1 2
Bsn.
Hn. (F) 1 2
Tpt. (B♭) 1 2
Tbn. 1 2
Timp.
Perc.
Cym.
Solo Tuba
Vln. I
Vln. II
Vla.
Vc.
Db.
cresc.
pizz.
pizz., non div.
p cantabile

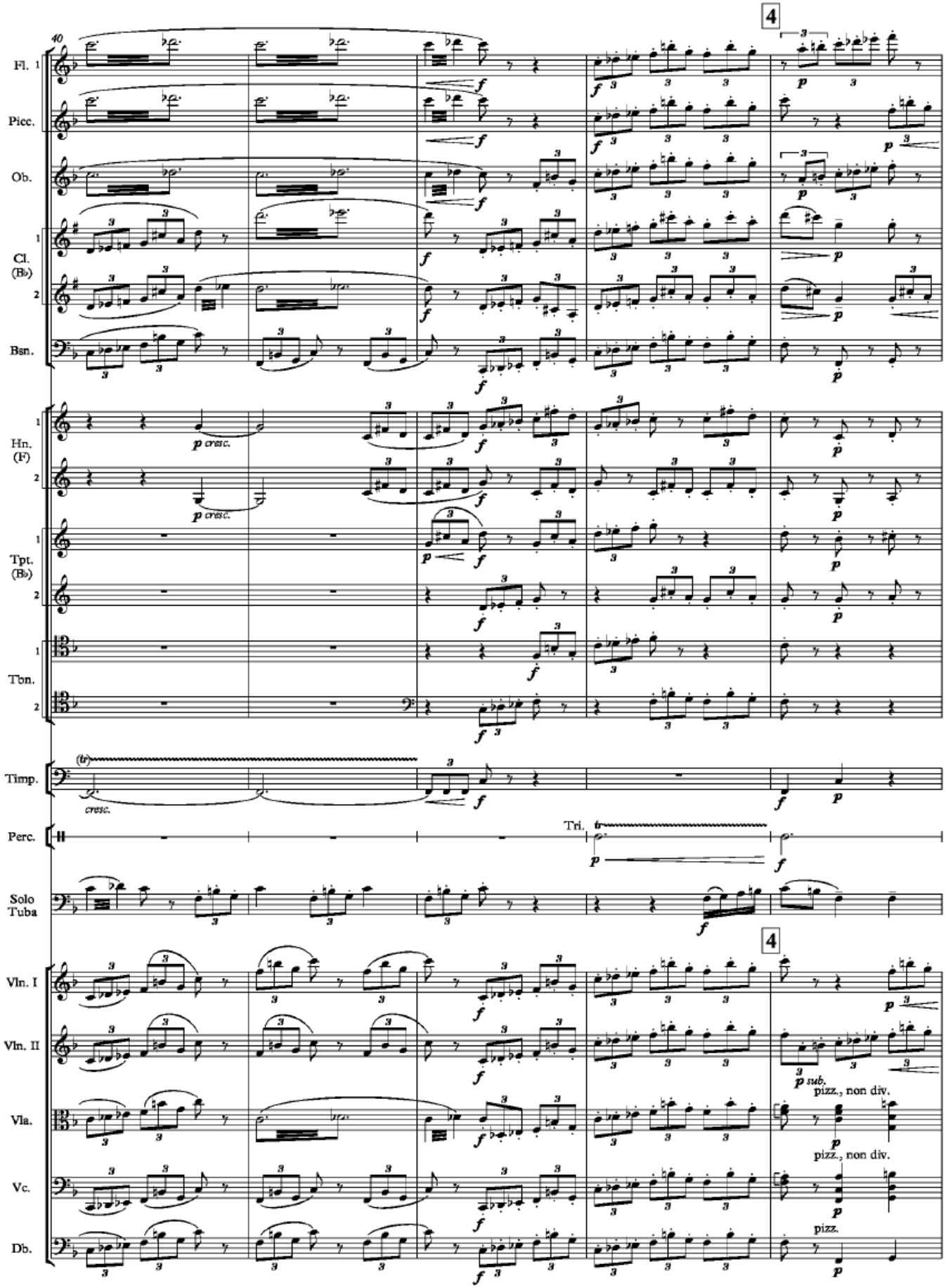

13
Fl. 1
Picc.
Ob.
1
Cl. (B♭)
2
Bsn.
Hn. 1 2 (F)
Tpt. 1 2 (B♭)
1
Tbn.
2
Timp.
Solo Tuba
Vln. I
Vln. II
Vla.
Vc.
Db.
f
tr
arco

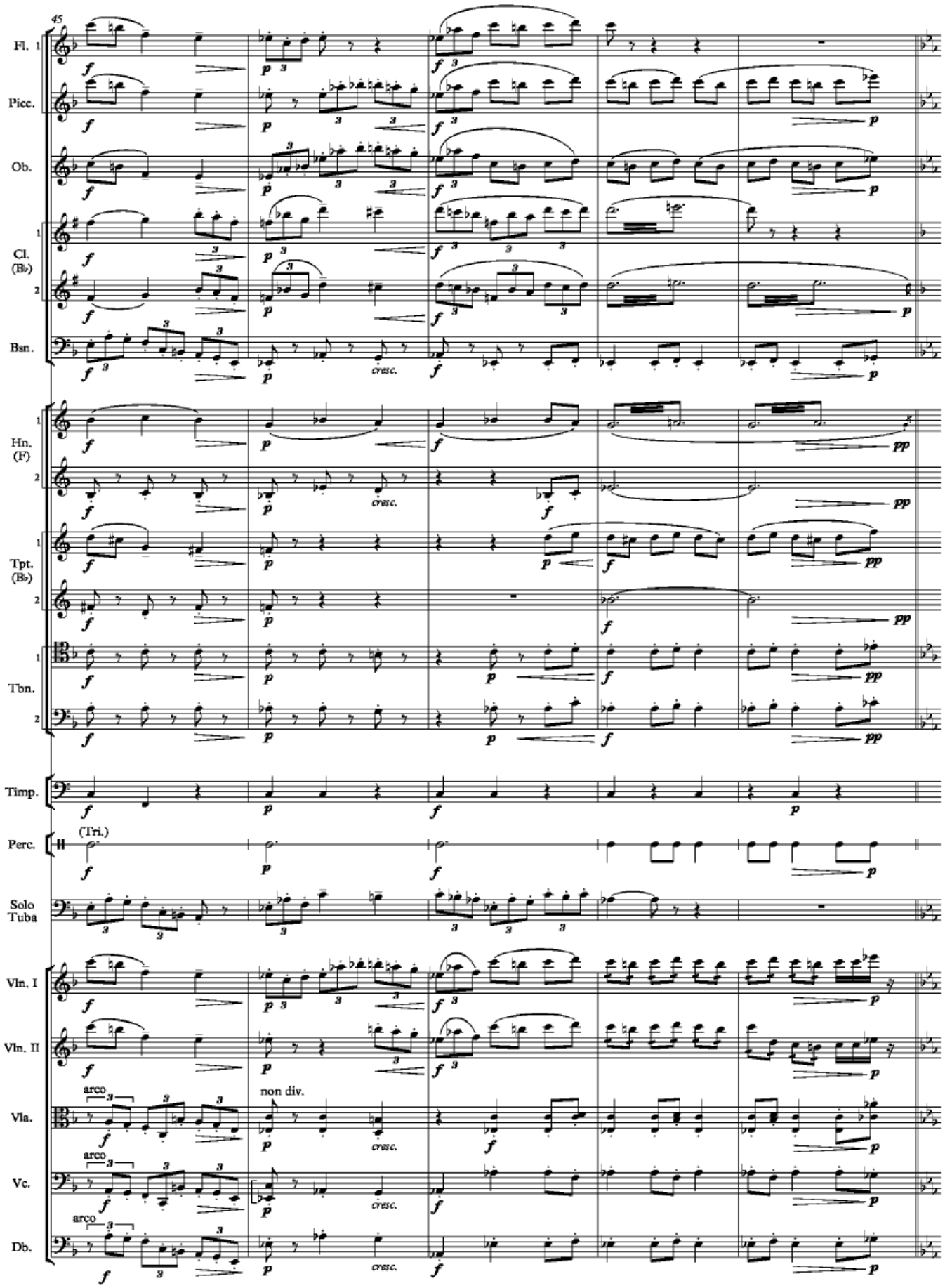

20
2
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
Cl. (B♭) 2
Bsn.
Hn. (F) 1
Hn. (F) 2
Tpt. (B♭) 1
Tpt. (B♭) 2
Tbn. 1
Tbn. 2
Timp.
Perc.
Tri.
Solo Tuba
2
Vln. I
Vln. II
Vla.
Vc.
Db.
arco
arco
arco

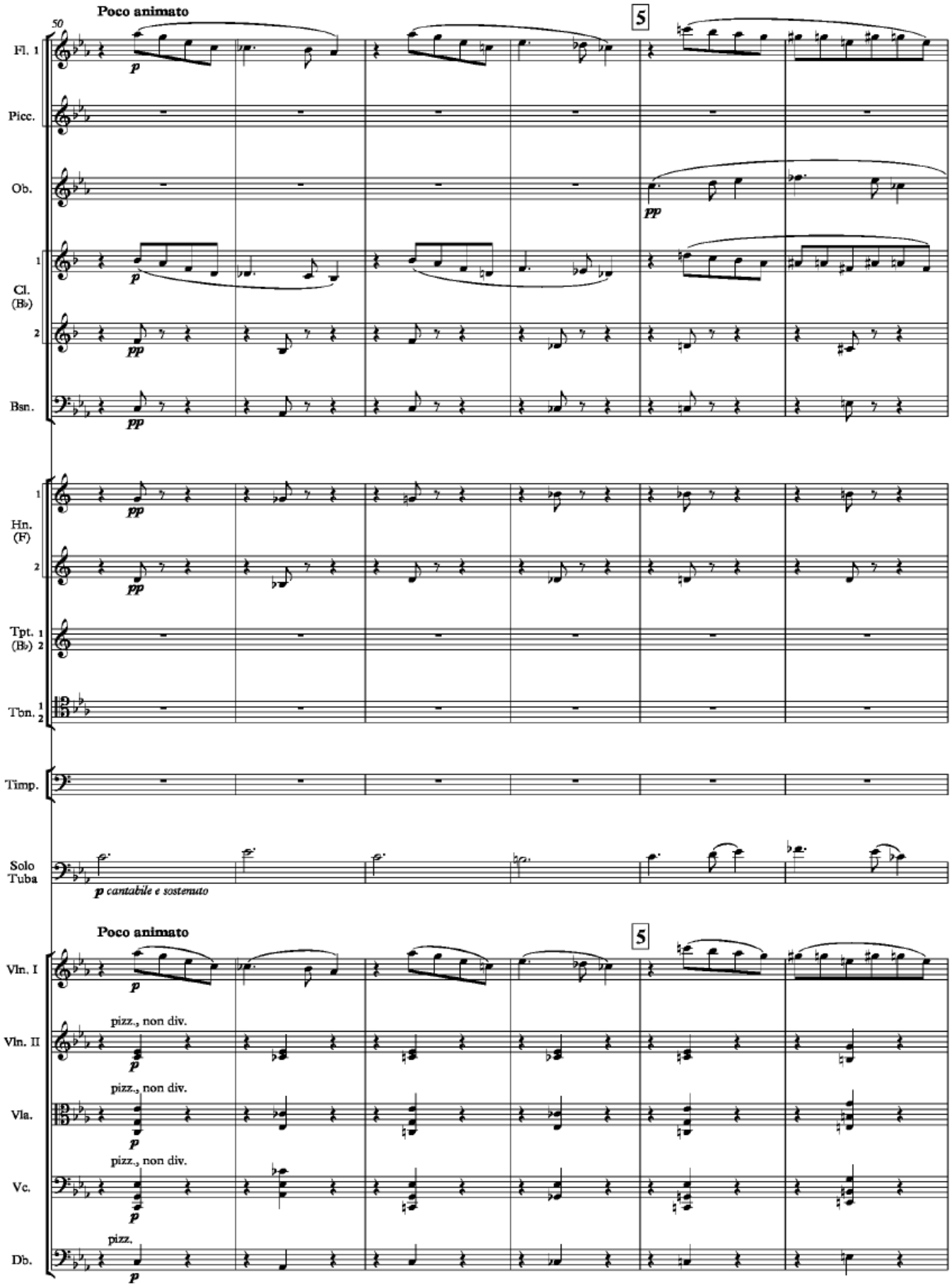

Poco animato
25
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
Cl. (B♭) 2
Bsn.
Hn. (F) 1
Hn. (F) 2
Tpt. (B♭) 1
Tpt. (B♭) 2
Tbn. 1 2
Timp.
Perc.
Solo Tuba
Poco animato
div.
Vln. I
Vln. II
Vla.
Vc.
Db.
unis.
pizz.
pp
p

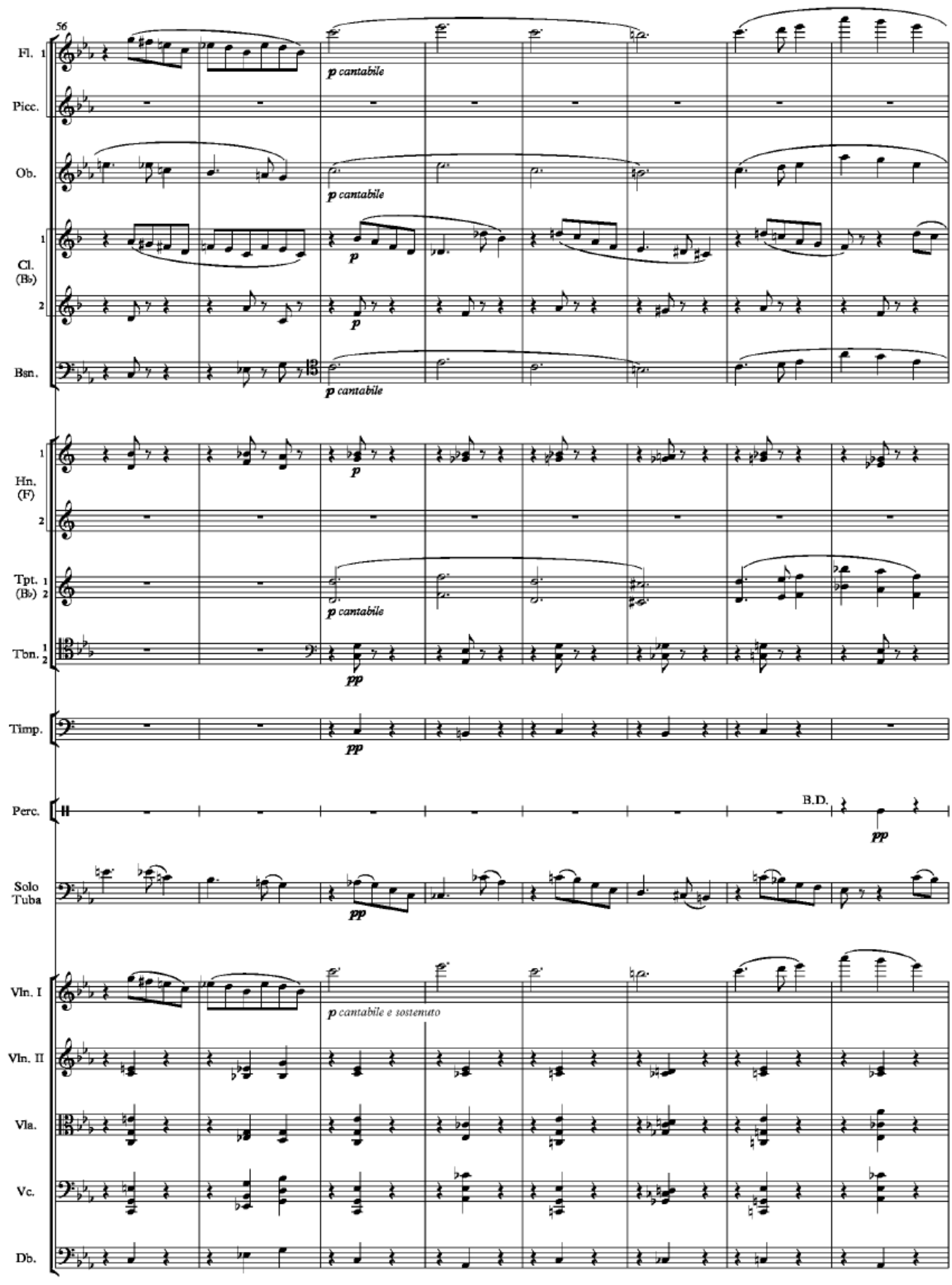

30
3
Fl. 1
Picc.
pp
Ob.
1
Cl. (B♭)
2
Bsn.
1
Hn. (F)
2
Tpt. (B♭) 1 2
Tbn. 1 2
Timp.
Solo Tuba
mf
3
Vln. I
Vln. II
Vla.
div.
unis.
div.
unis.
Vc.
Db.

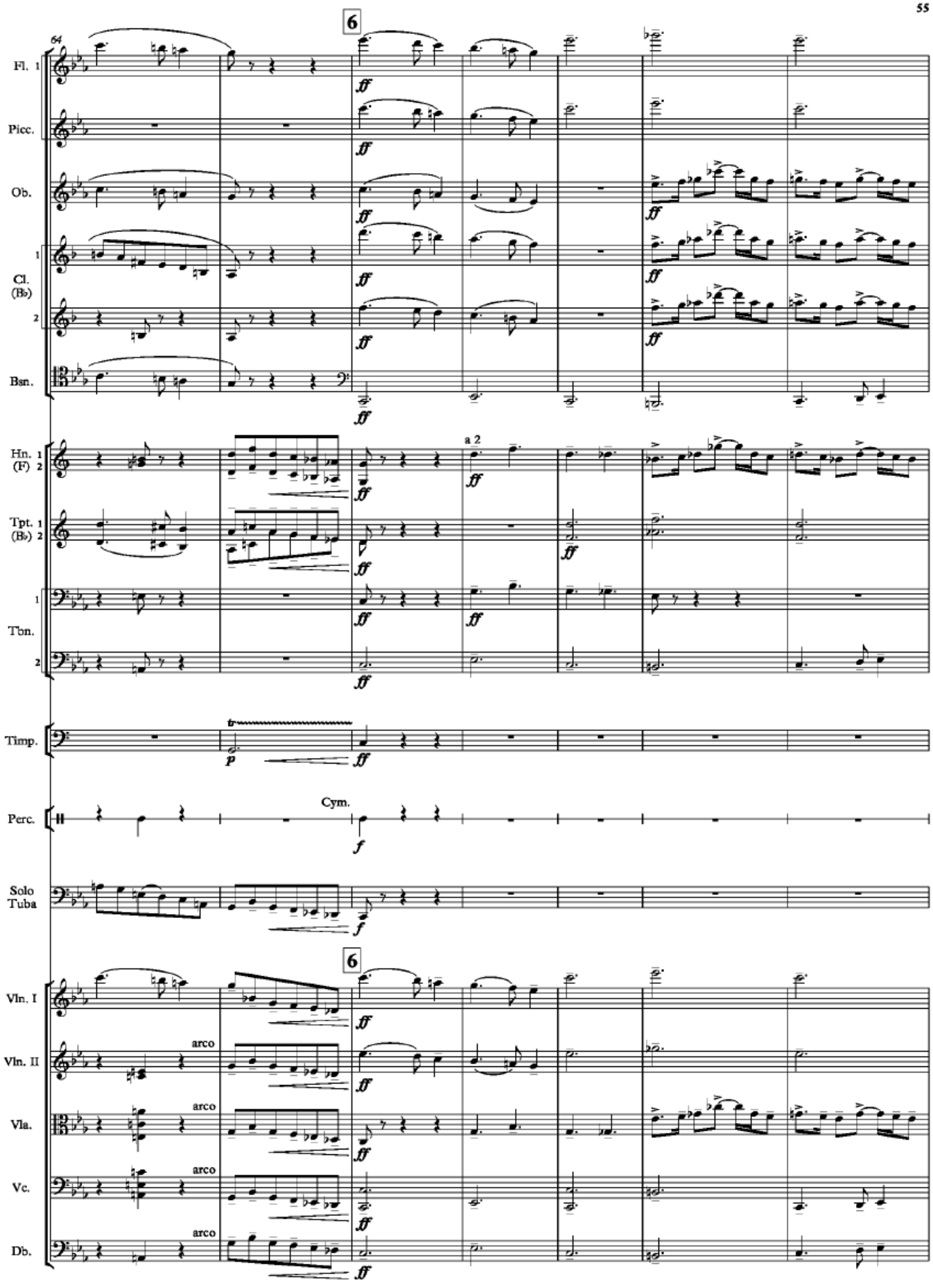

35
Tempo primo
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1
2
Tbn. 1
2
Timp.
Solo Tuba
Tempo primo
Vln. I
Vln. II
Vla.
Vc.
Db.
f
fp
p cresc.
unis.
non div.
arco

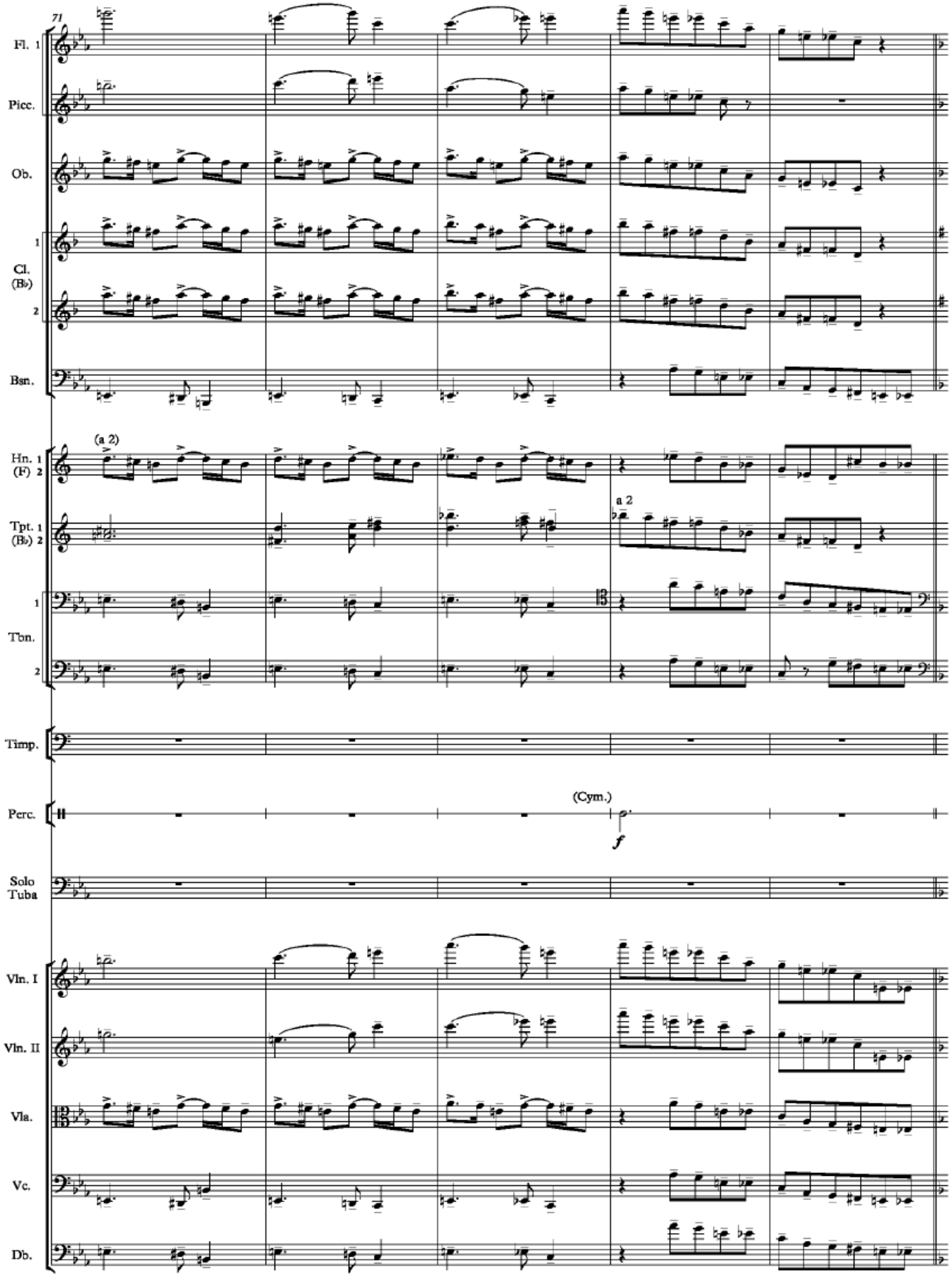

40
4
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
Cl. (B♭) 2
Bsn.
Hn. (F) 1
Hn. (F) 2
Tpt. (B♭) 1
Tpt. (B♭) 2
Ten. 1
Ten. 2
Timp.
Perc.
Tri.
Solo Tuba
Vln. I
Vln. II
Vla.
Vc.
Db.
p cresc.
cresc.
p sub.
pizz., non div.
pizz.

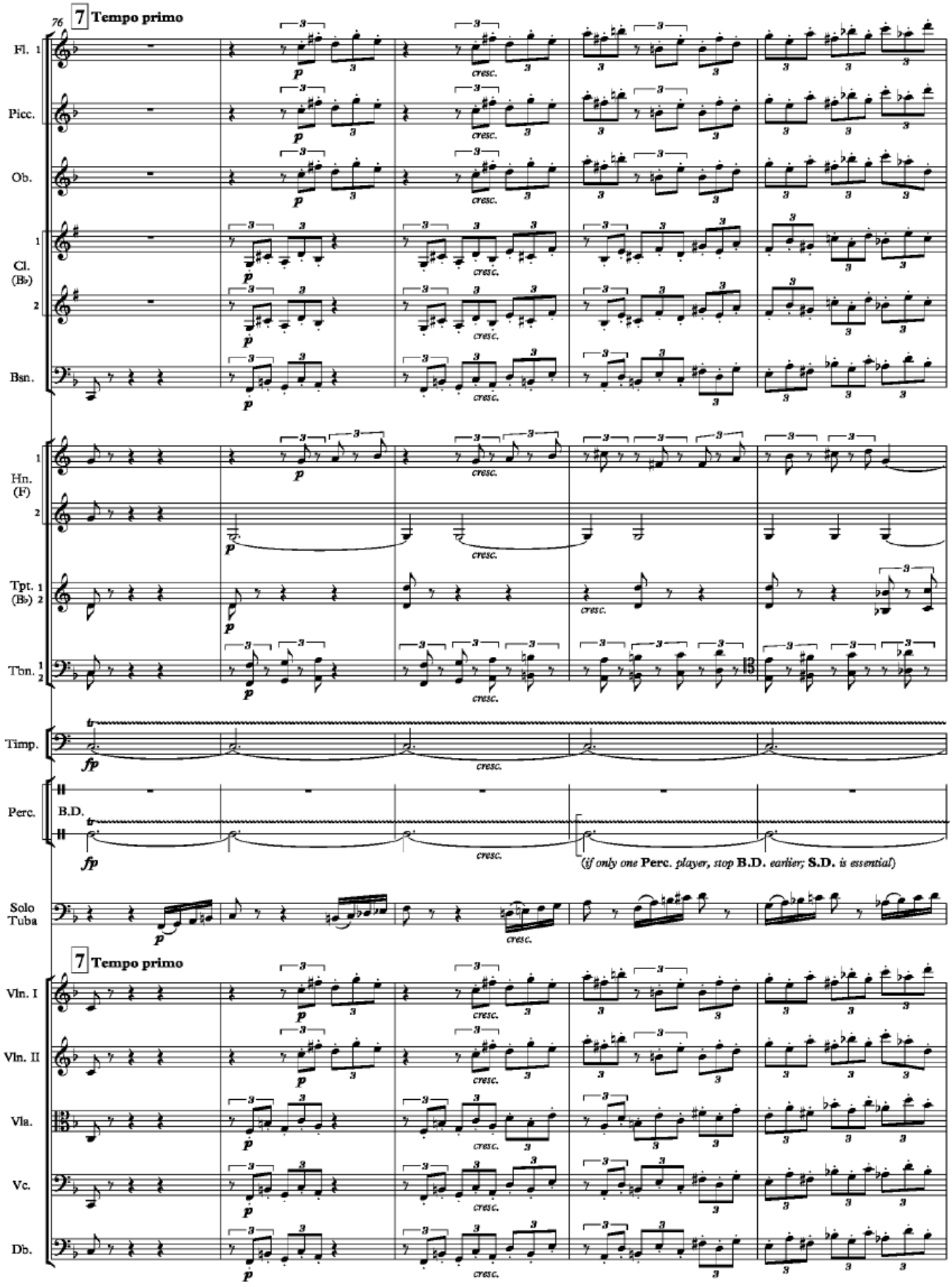

45
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
Cl. (B♭) 2
Bsn.
Hn. (F) 1
Hn. (F) 2
Tpt. (B♭) 1
Tpt. (B♭) 2
Tbn. 1
Tbn. 2
Timp.
Perc.
(Tri.)
Solo Tuba
Vln. I
Vln. II
Vla.
Vc.
Db.
arco
non div.
cresc.

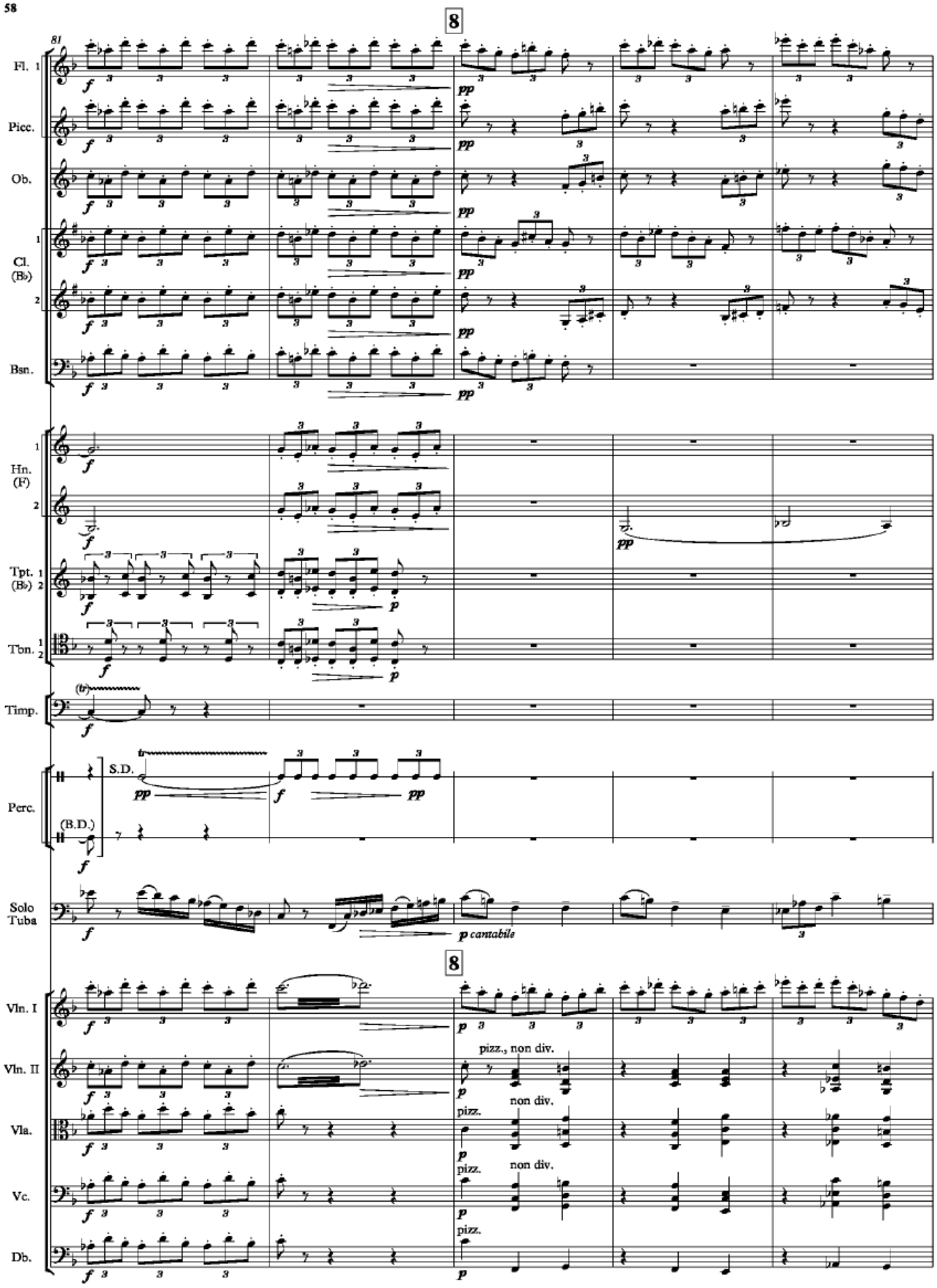

50
Poco animato
5
Fl. 1
Picc.
Ob.
pp
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1 2
Tbn. 1 2
Timp.
Solo Tuba
p cantabile e sostenuto
Poco animato
5
Vln. I
Vln. II
pizz., non div.
Vla.
pizz., non div.
Vc.
pizz.
Db.

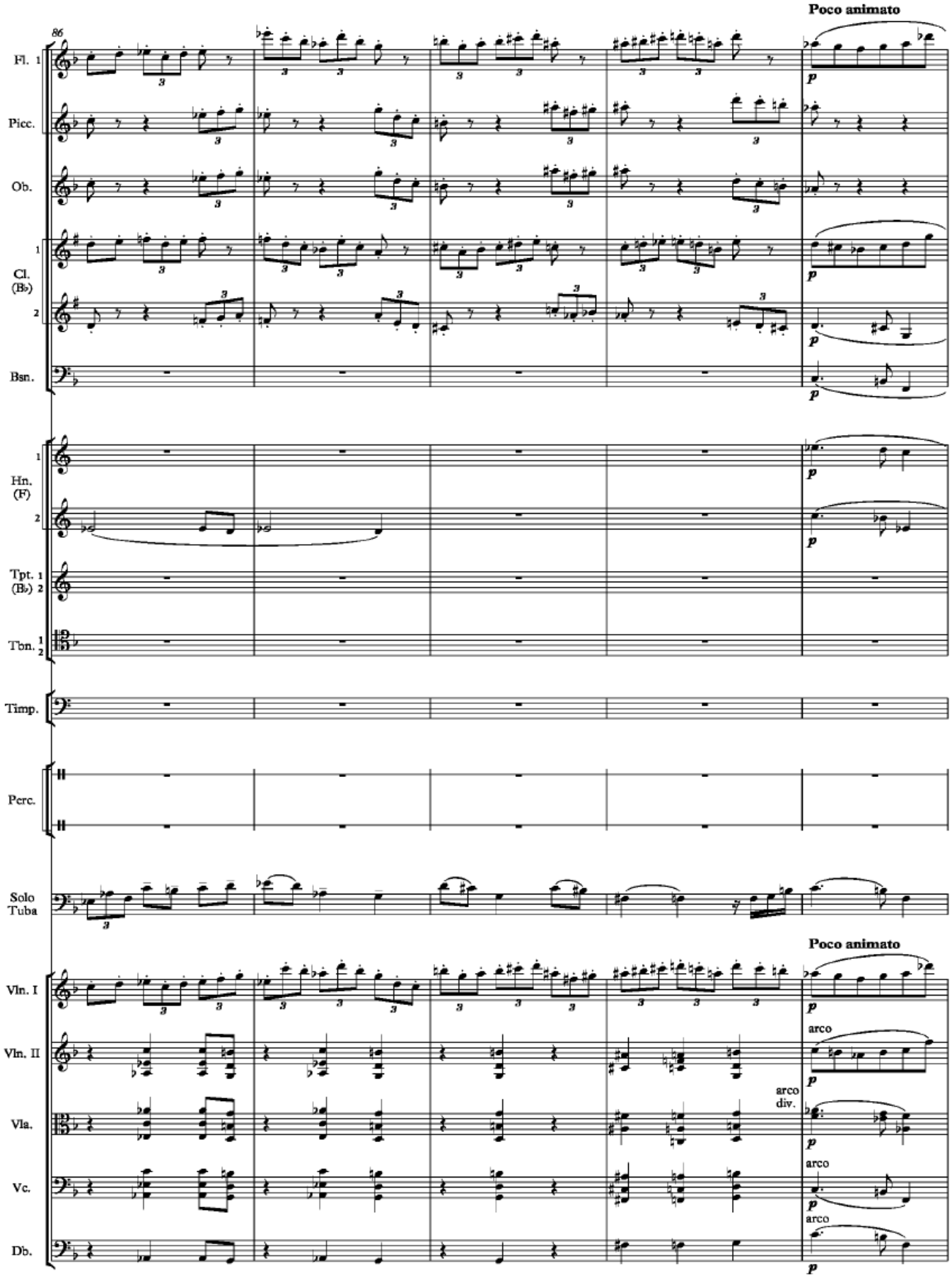

56
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1 2
Tbn. 1 2
Timp.
Perc.
Solo Tuba
Vln. I
Vln. II
Vla.
Vc.
Db.
p cantabile
p
pp
B.D.
p cantabile e sostenuto

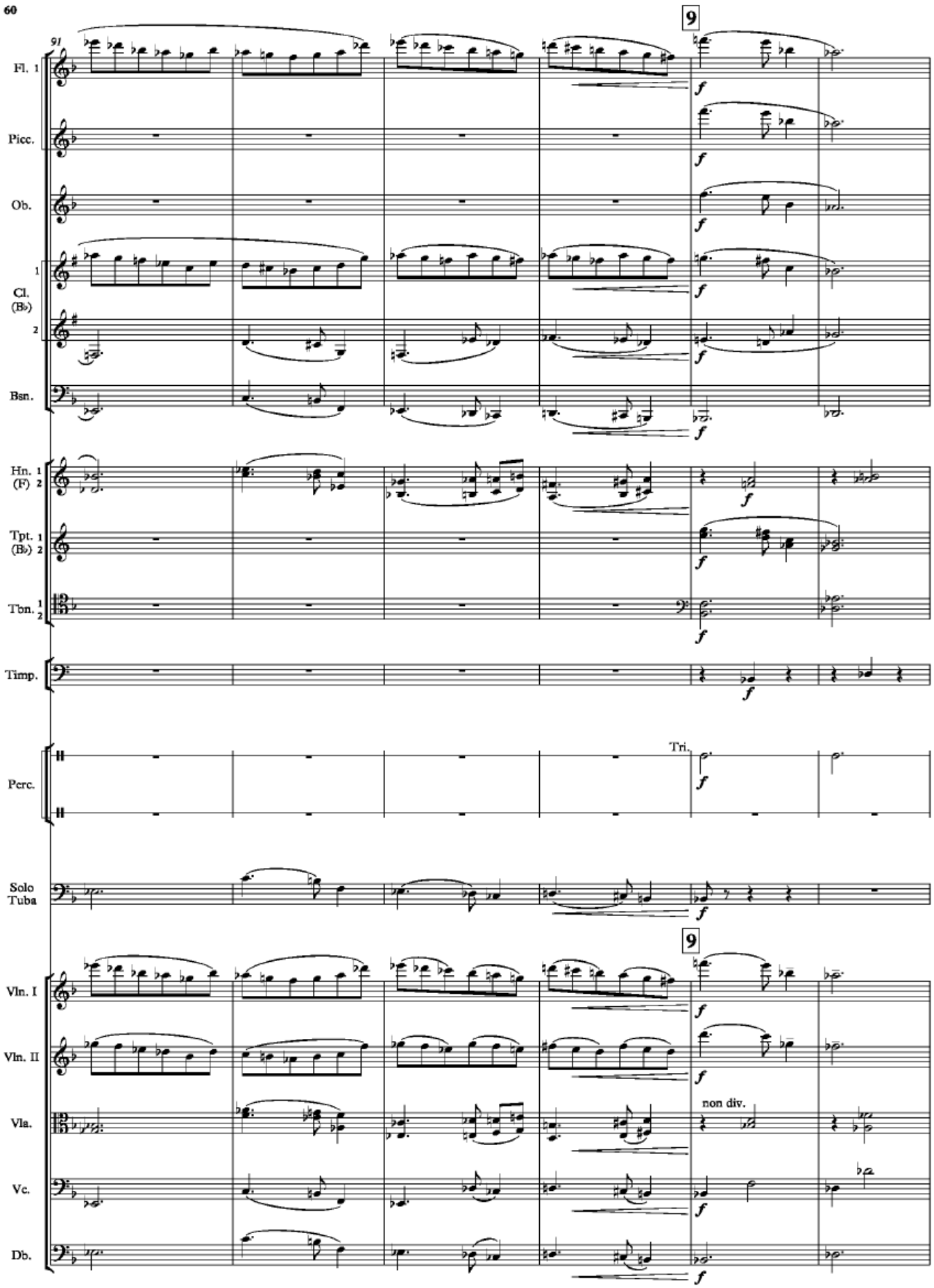

64
6
Fl. 1
Picc.
Ob.
1
Cl. (B♭)
2
Bsn.
Hn. 1 2 (F)
a 2
Tpt. 1 2 (B♭)
1
Tbn.
2
Timp.
Perc.
Cym.
Solo Tuba
6
Vln. I
Vln. II
arco
Vla.
arco
Vc.
arco
Db.
arco
ff
p
f

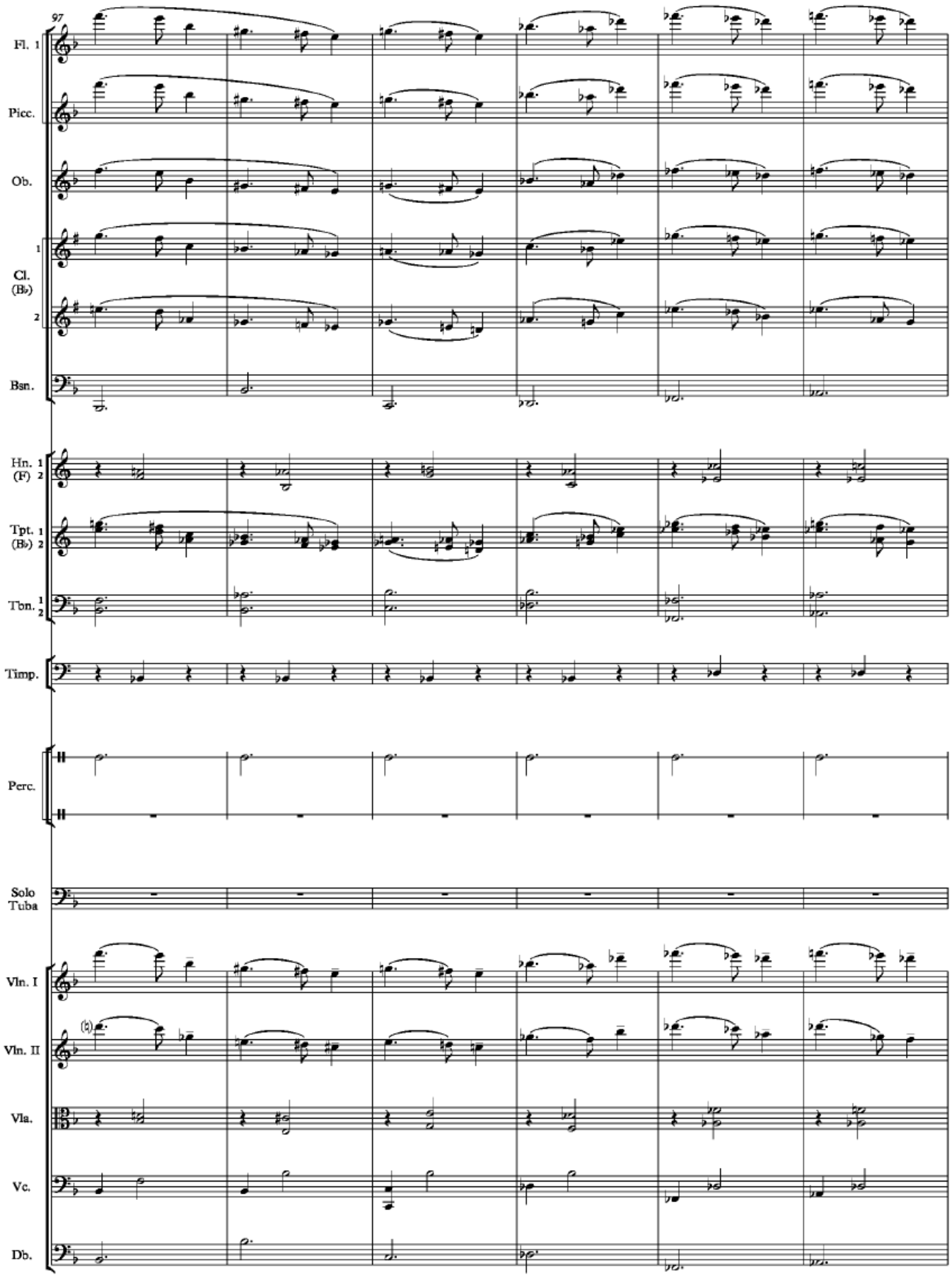

71
Fl. 1
Picc.
Ob.
1
Cl. (B♭)
2
Bsn.
(a 2)
Hn. 1 (F) 2
Tpt. 1 (B♭) 2
a 2
1
Tbn.
2
Timp.
(Cym.)
f
Perc.
Solo Tuba
Vln. I
Vln. II
Vla.
Vc.
Db.

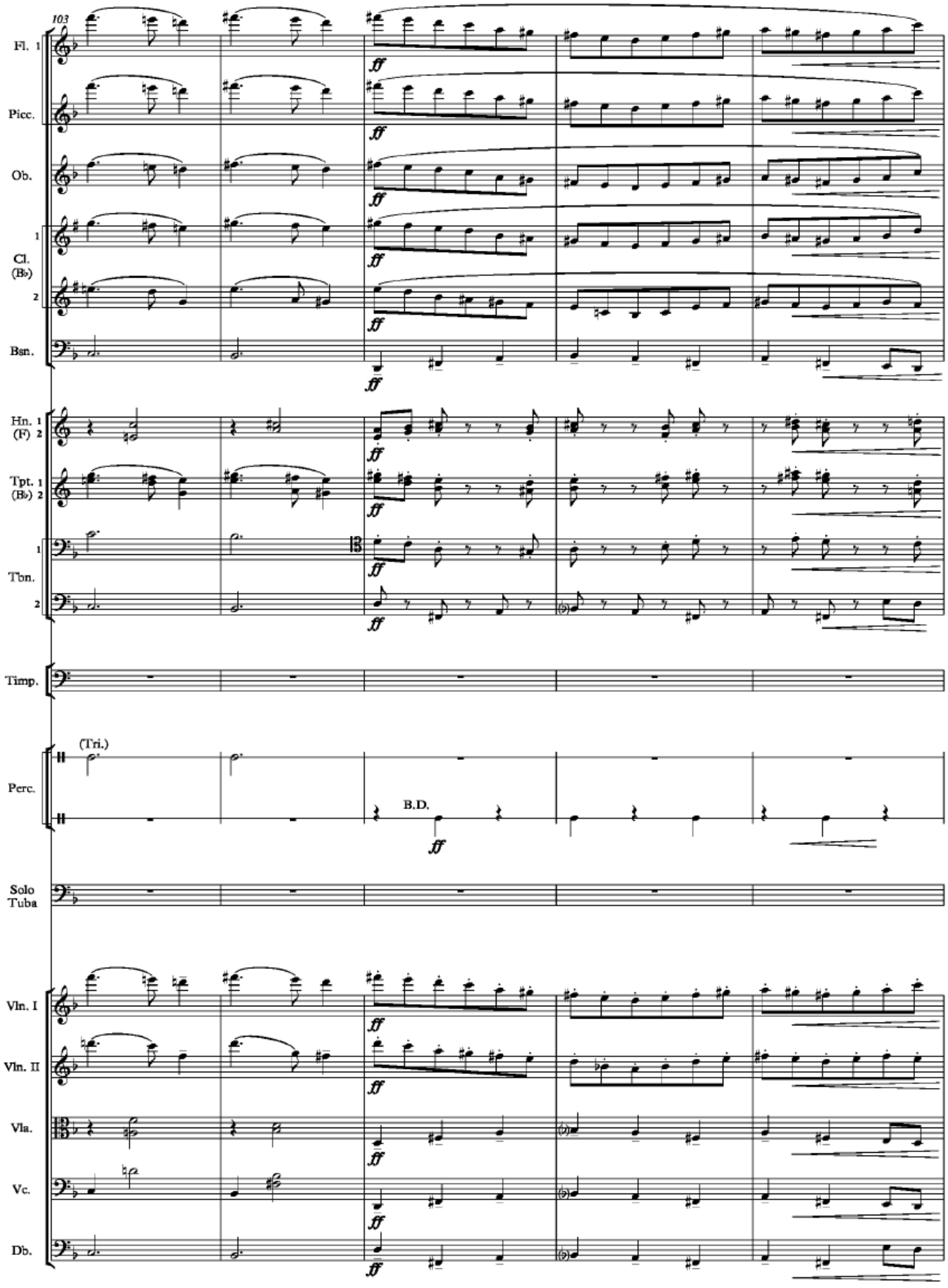

76
7 Tempo primo
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1 2
Tbn. 1 2
Timp.
Perc.
B.D.
(if only one Perc. player, stop B.D. earlier; S.D. is essential)
Solo Tuba
7 Tempo primo
Vln. I
Vln. II
Vla.
Vc.
Db.
p
fp
cresc.

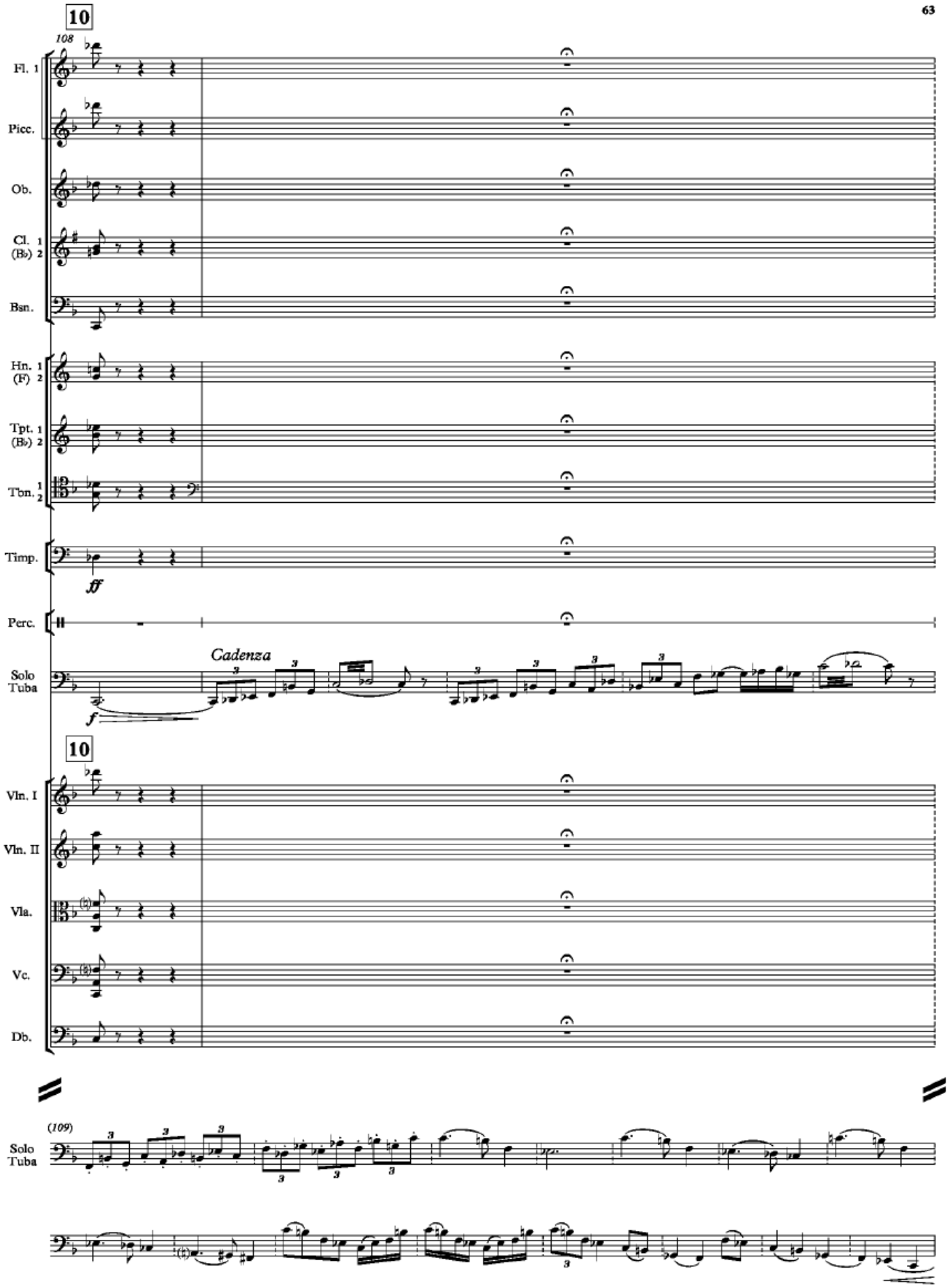

81
8
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1 2
Tbn. 1 2
Timp.
Perc.
S.D.
(B.D.)
Solo Tuba
p cantabile
8
Vln. I
Vln. II
Vla.
Vc.
Db.
pizz., non div.
pizz.
non div.
pizz.
non div.
pizz.

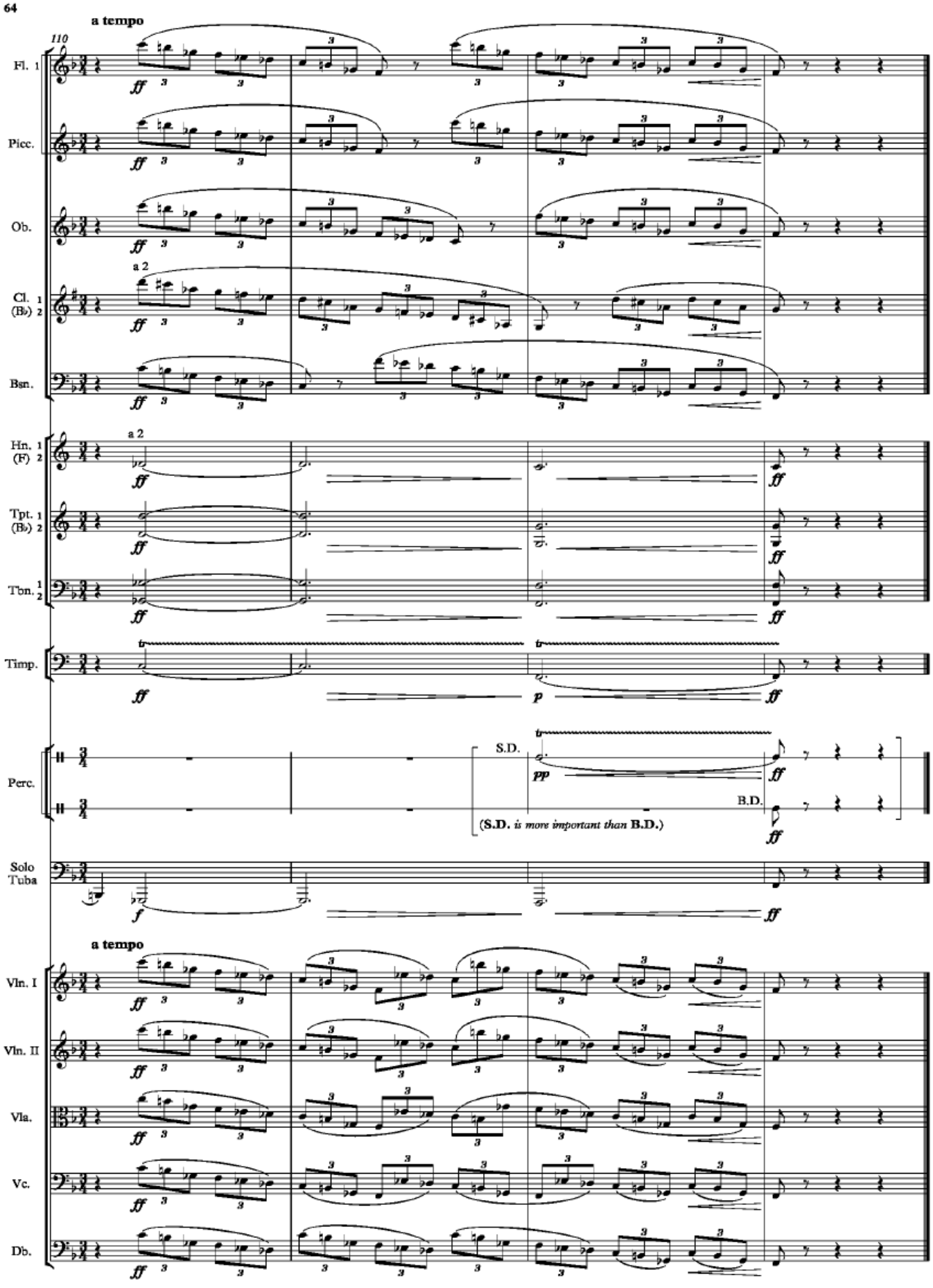

Poco animato
86
Fl. 1
Picc.
Ob.
Cl. (B♭) 1
2
Bsn.
Hn. (F) 1
2
Tpt. (B♭) 1 2
Tbn. 1 2
Timp.
Perc.
Solo Tuba
Poco animato
Vln. I
Vln. II
Vla.
Vc.
Db.
arco
arco div.
arco
arco
p


91
9
Fl. 1
Picc.
Ob.
1
Cl. (B♭)
2
Bsn.
Hn. 1 (F) 2
Tpt. 1 (B♭) 2
Tbn. 1 2
Timp.
Tri.
Perc.
Solo Tuba
9
Vln. I
Vln. II
non div.
Vla.
Vc.
Db.
f


97
Fl. 1
Picc.
Ob.
1
Cl. (B♭)
2
Bsn.
Hn. 1 2 (F)
Tpt. 1 2 (B♭)
Tbn. 1 2
Timp.
Perc.
Solo Tuba
Vln. I
Vln. II
Vla.
Vc.
Db.


103
Fl. 1
Picc.
Ob.
1
Cl. (B♭)
2
Bsn.
Hn. 1 (F) 2
Tpt. 1 (B♭) 2
1
Tbn.
2
Timp.
(Tri.)
Perc.
B.D.
Solo Tuba
Vln. I
Vln. II
Vla.
Vc.
Db.
ff


10
108
Fl. 1
Picc.
Ob.
Cl. 1 (B♭) 2
Bsn.
Hn. 1 (F) 2
Tpt. 1 (B♭) 2
Tbn. 1 2
Timp.
ff
Perc.
Solo Tuba
Cadenza
f
10
Vln. I
Vln. II
Vla.
Vc.
Db.
(109)
Solo Tuba


a tempo
110
Fl. 1
Picc.
Ob.
a 2
Cl. 1 (B♭) 2
Bsn.
a 2
Hn. 1 (F) 2
Tpt. 1 (B♭) 2
Tbn. 1 2
Timp.
Perc.
S.D.
B.D.
(S.D. is more important than B.D.)
Solo Tuba
a tempo
Vln. I
Vln. II
Vla.
Vc.
Db.