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The Influence of Gouge and Shape on Pitch and Tone Quality of the Oboe.

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THE INFLUENCE OF GOUGE AND SHAPE ON PITCH AND TONE QUALITY OF THE OBOE

VOLUME I

A Monograph

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c. 2

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ABSTRACT

This work is a study of the gouge and shape of oboe reeds and their influence on pitch and tone quality.

The first part of the study included a description of the gouging and shaping processes, a comparison of gouging machines by Claude Reynolds and F. Kunibert Michel, and a definition of two contrasting gouging techniques.

One technique features a symmetrical relationship between the gouger blade and guides. The blade's cutting contour conforms to a radius which roughly matches the desired gouge contour. The contrasting technique features an asymmetrical blade which is displaced slightly with respect to the guides. The cutting action takes place towards one side of the cane surface which necessitates the reversal of cane to produce a symmetrical contour.

The second part, the study of the influence of gouge and shape on pitch and tone quality, applied the two contrasting gouging techniques. The null hypothesis was applied to the two questions relating to the influence on (1) pitch, and (2) tone quality. Four groups of twelve experimental reeds were made with cane featuring thick gouge (.024 inch at center, .018 inch at edge), thin gouge (.023 inch at center, .015 inch at edge), narrow shape (.273 inch at shaper tip), and wide shape (.315 inch at shaper tip).

The analysis of playing quality was restricted to the parameters of pitch and tone quality with tests limited to six selected pitches (d, g, c^1, f^1, bb^1, and eb^2). The analysis of pitch was made with a Stroboconn Tuning Unit and the analysis of tone quality was made with a Spectrum Analyzer. Data were analyzed at the Northeast Regional Data Center executing the ANOVA Statistical Analysis System.

The results of the study indicate that pitch and tone quality of oboe reeds are influenced by the gouge and the shape of the cane. The overall pitch deviation in cents from the reference level of a = 440 Hz is as follows: Group I = +1.09, Group II = -5.01, Group III = -1.01, and Group IV = -1.79. The influence of the gouge is illustrated by the comparison of the grand deviations between the two gouge groups, measuring -3.92 cents for the thick gouge group and -2.80 cents for the thin gouge group. The influence of the shape is demonstrated by a grand deviation of +0.08 cents with the narrow shape and -6.80 cents with the wide shape. The null hypothesis was rejected.

The analysis of tone quality was determined by the statistical analysis of the mean values, indicating that the difference in tone quality among the four reed groups was slight and not statistically significant. The analysis, based on a .05 level of confidence, demonstrated that 11 of 114 data points (9.6 per cent) exhibited significant differences. The null hypothesis was accepted.

Observations made on the basis of subjective evaluations and comparisons of spectrum envelopes indicated that thick gouges and narrow shapes produced brighter tonal quality while thin gouges and wider shapes resulted in darker quality. Subjective evaluation of

the individual reeds indicated that: 50 per cent of the Group I reeds were judged to exhibit good playing quality, 25 per cent of the Group II reeds were marginally acceptable, 66 per cent of the Group III reeds were rated good, and 33 per cent of the Group IV reeds demonstrated some good qualities.

Since the aspects of reedmaking, performance, and tonal quality are imbued with personal subjectivity, the correlation of the results of the reed evaluations with the conclusions of the study indicates the truly significant influences that the gouge and shape exert on pitch and tone quality.

CHAPTER I

INTRODUCTION

Scope and Delimitations

"It is the combined skills of the carpenter, the mechanic, and the musician which produce an oboist."[1] It is in the spirit of these words by the venerable oboist, Leon Goossens, that this study is undertaken involving the reed and its influence on tonal quality of the oboe.

The process of performing on a woodwind instrument, particularly the oboe, is inextricably tied to the sound-producing agent, the reed. The oboe reed is comprised of two elongated pieces of cane that are fixed at one end and are free to vibrate at the other end. The best cane reeds are made from Arundo donax, a species of tall grass grown in the Fréjus region of Southern France, as well as areas in Spain, Italy, Greece, Africa, and the United States. Oboe reeds are representative of the heterophonic type of reed mechanism. Heterophonic reeds are capable of producing a wide range of pitches when connected to a pipe whose length determines the pitches. The oboe reed, a double reed, features two reeds bound to a metal tube (or staple), separated by a slight opening, which vibrate against each other.[2]

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[1]Leon Goossens and Edwin Roxburgh, Oboe (New York: Schirmer Books, A Division of Macmillan Publishing Co., Inc., 1977), p. 1.

[2]Willi Apel, Harvard Dictionary of Music (2nd ed., rev.; Cambridge: Belknap Press of Harvard University Press, 1969), pp. 720-21.

The total sound or tonal quality of the oboe in performance is largely attributed to the reed mechanism. The reed functions in conjunction with the bore of the instrument as an integral unit in the production of oboe tone. "The combination of good wood and correct bore measurements add [sic] very much to the quality of tone produced; however, the reed plays an important part."[3] Another comment illustrating the importance of the reed is found in Baines' Woodwind Instruments and Their History. "Oboists . . . are entirely dependent upon a short-lived vegetable matter of merciless capriciousness, with which, however, when it behaves, are wrought perhaps the most tender and expressive sounds in all music."[4]

Since the reed is such a critical factor in the tone production of the oboe, the handcrafting of reeds has become an essential aspect of performance. Over ninety per cent of the world's great oboists feel that making one's own reeds is of paramount importance to successful performance.[5] Some of the many reasons for hand production of reeds are: (1) no presently available commercially-made reed suits the needs of all performers; (2) reeds are, as noted above, quite impermanent; (3) reeds must complement the playing style of the performer, since they affect such elements as breath support, embouchure, intonation, dynamics, articulation, response, and tone quality; and (4) reeds must suit the performer's aural concept of tone quality.

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[3]Earnest Harrison, "The Oboe and English Horn" in The Story of Musical Instruments, ed. by Frederic Fay Swift (Oneonta, N.Y.: Swift-Dorr Publications, Inc., 1973), p. 52.

[4]Anthony Baines, Woodwind Instruments and Their History (2nd ed., New York: W.W. Norton and Co., Inc., 1962), p. 76.

[5]Robert Sprenkle and David Ledet, The Art of Oboe Playing (Evanston, Illinois: Summy-Birchard Company, 1961), p. 41. The number is greater for American oboists as it is more common for European not to make their own reeds.

The process of oboe reedmaking involves several stages from the cane's origin as a tube of *Arundo donax*. A basic outline of the procedure includes:

(1) Splitting the tube into three lengthwise strips with an arrow splitter
(2) Cutting each strip to proper length utilizing a guillotine
(3) Pregouging cane, trimming, and narrowing each strip to fit into the bed of the gouging machine
(4) Gouging--removing the soft, spongy cane, leaving cane closest to the bark side
(5) Folding at mid-point, bark side out
(6) Shaping the width of the cane to the desired outline of the reed
(7) Binding the shaped cane with string to the staple
(8) Separating the tip by clipping
(9) Scraping the blades of the reed

The physical dimensions of the reed cane exert a strong influence on the tonal quality of the oboe. This principle is similarly demonstrated in the technique of voicing the reed pipes of a pipe organ. Voicing those particular pipes of an organ involves the adjustment of the reed and other elements of the pipe to produce a desired tonal quality or timbre. The dimensions (or shape) of the reed "constitute one of the most important phases of the voicing process."[6] Similarly, the oboe reed works in conjunction with its bore to determine the basic tonal quality of the instrument, although the oboe reed mechanism is constructed from cane rather than the metal used in organ reeds. Oboe reed cane assumes its finished proportions as the result of a reciprocal process of gouging, shaping, and scraping. Each of these processes has a direct bearing on subsequent stages of reedmaking and ultimately on the resultant quality of the oboe's tone.

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[6]Charles A. Culver, *Musical Acoustics* (4th ed., New York: McGraw-Hill Book Company, Inc., 1956), p. 194.

Oboe reed cane, by its organic nature, has numerous variable factors. The scope of this study was confined to the processes of gouge and shape since they represent the principal determinants of the basic dimensions of the reed cane.

The gouge of the cane represents the inner contour of the reed. Gouged cane is thickest in the center and graduates evenly to the thinner sides. The gouge contour is variable, depending on the shape of the gouger blade, its relationship with the guides on the gouger's carriage, and its setting in the machine.

The shape, another variable aspect, refers to the width of the reed and the rate at which the reed cane narrows. Oboe cane is shaped in such a way that the widest point is at the top of the reed and tapers to its thinnest point where the cane is bound to the staple (under the string). The critical aspects of the shape's dimensions are the width at or near the top (where the reed's tip will ultimately fall), the width at the binding immediately above the string (called the "throat"), and the rate of taper. "When coupled with a particular gouge measurement, staple, instrument, and embouchure, the shape of the reed becomes an important link in the chain of sound-producing equipment."[7]

The musical-acoustical variables involved in a study of reeds are manifold. Many are highly subjective, others are difficult to define and record, and some involve the use of sophisticated equipment not readily available. As a result, the parameters of musical quality considered in this study were confined to pitch and to tone quality (timbre). These are basic acoustical phenomena, are least subjective,

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[7] Sprenkle and Ledet, <u>The Art of Oboe Playing</u>, p. 63.

and lend themselves best to tests and measurements with the equipment presently available to the writer.

Even as long ago as 1752, J. J. Quantz, in his treatise On Playing the Flute, reflected on the importance of the proportions of the reed: "As to the tone on both of these instruments [the oboe and bassoon], much depends upon a good reed, that is, whether it is made of good and seasoned wood, whether it has the proper concavity, whether it is neither too wide nor too narrow, neither too long or too short, and whether, when shaved, it is made neither too thick nor too thin. If the front of the reed is too wide and too long, the high notes become too low in relation to the low ones; but if it is too narrow and too short, they become too high."[8] It is evident that even two hundred years later the basic question concerning the influence of gouge and shape on pitch and tone quality is recognized but requires clarification and resolution.

Methods of Research

This study employed the descriptive and experimental methods of research. The problem concerning this study involved the question of whether the relationship between the dimensions of reed cane and resultant tone quality can be codified and applied to musical practice. The null hypothesis was used to determine whether there is (1) an influence of gouge and shape on pitch, and (2) an influence of gouge and shape on tone quality. The first objective was to systematically report facts relative to the gouging and shaping

[8]Johann Joachim Quantz, On Playing the Flute, trans. by Edward R. Reilly (New York: The Free Press, Faber and Faber, 1966), pp. 85-86.

processes of preparing oboe reed cane. Included are descriptions of the gouging and shaping procedures in general, descriptions and comparisons of the tools and machinery involved in these procedures and their mechanics of operation, and descriptions of specific concepts and principles regarding the methodology of gouging and shaping. The second objective was to determine analytically what relationship (if any) exists between the dimensions of the reed cane and the resultant tonal quality of the oboe. This relationship was determined through the application of the above material regarding gouge and shape. The research included samplings of reed cane prepared with variable dimensions of gouge and shape. Acoustical measurements were made on the basis of performance on the finished reeds made from the experimental cane samples.

The research employed a quasi-experimental design containing features of the counterbalanced and equivalent time-sample designs incorporated in a modified Latin square arrangement. The scheme is diagrammed as follows:

	Time 1	Time 2	Time 3	Time 4
Group I (Gouge X)	$nX_1 0$*	$nX_2 0$	$nX_3 0$	$nX_4 0$
Group II	$wX_1 0$	$wX_2 0$	$wX_3 0$	$wX_4 0$
Group III (Gouge Y)	$nY_1 0$	$nY_2 0$	$nY_3 0$	$nY_4 0$
Group IV	$wY_1 0$	$wY_2 0$	$wY_3 0$	$wY_4 0$

*Note: n = narrow; w = wide

A total of forty-eight reeds were made, twelve for each of the four experimental settings, or groups, of reeds. The experiment required four test times (time-sample design). In each test, three reeds were sampled from each group. Delimiting factors were that each reed must

play as closely as possible to the pitch level a = 440, and the octave "crow" of each reed was tuned as closely as possible to the pitch c.

Experimental cane samples were prepared with variable gouge and shape dimensions. The experimental design diagram featured cane gouged to two contrasting gouge contours. Cane from each of the two gouge contour categories was then shaped to one of the two shaper contours. The experiment entered all settings (gouge) into all treatments (shape).

Acoustical measurements of each finished reed were made. The parameters of measurements included those of pitch and tone quality, which were made through the use of a spectrum analyzer. The apparatus is described more fully below. The kind of data recorded by the spectrum analyzer was visually described through the use of a "loudness spectrum or loudness recipe,"[9] a graph which plots the strengths of the partials and the pitch levels of each. This graph was projected onto the screen of the spectrum analyzer and simultaneously recorded on graph paper by an attached X/Y recorder. The acoustical measurements were made on specific tones selected as being representative of the various registers and representative of various bore or tube lengths of the instrument. The circle of fourths provided a convenient mechanism for achieving these criteria. The pitches selected were d, g, c^1, f^1, b^{b1}, and e^{b2} (c = middle c).

All experiments and collection of data took place in the University of Florida Department of Music Electronic Music Studio. The studio is designed acoustically for recording with carpeted floors, acoustical tile ceiling, and an irregular wall configuration. The

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[9]Arthur H. Benade, <u>Fundamentals of Musical Acoustics</u> (New York: Oxford University Press, 1976), pp. 370-71.

personnel involved in this study along with the author were Donald Carlson, the technician in the acoustical experiments, and Dr. Stephen F. Olejnik, University of Florida Foundations in Education, the consultant for research design and computer research. The materials involved in this study included:

(1) Gouging maching: Claude F. Reynolds, serial No. 101
(2) Gouging machine: M. Kunibert Michel
(3) Oboe: Gordet, serial No. 693
(4) Oboe tube cane: Fréjus; diameter: medium/10.5 mm.
(5) Staples: 47 mm
(6) Microphone: AKG Acoustics Microphone, type C422, serial No. 312
(7) Pre-amplifier: Revox Tape Deck, model A77
(8) Spectrum Analyzer and X/Y Recorder: Hewlett-Packard, model No. 5314A
(9) Oscilloscope: Heathkit Dual Trace, model No. 10-4235
(10) Strobotuner: Stroboconn tuning unit, model 6T5, serial No. 6440, C. G. Conn, LTD
(11) Signal Generator: R. A. Moog, model series 900
(12) Computer: Northeast Regional Data Center, University of Florida

Data were recorded on Procedure Data forms prepared for this study. Included on the forms were: reed identification information, reed (or subject) number, group number, spectrum analysis results, reed dimension data, and a subjective evaluation of the performance of the reed. Reed dimension data included measurements of the gouged and shaped cane. Cane measurements were made at five points: the center, the two ribs (midpoint between center and shaper edge), and the two shaper edges. Reed dimensions also included the length of the finished reed. The subjective evaluation included the writer's comments regarding the aperture, crow, response, resistance, pitch, and tone quality of the finished reed.

Acoustical data were accumulated and interpreted. From the resulting loudness recipes obtained from the testing of each individual reed, a "spectrum envelope" was determined. The spectrum envelope, a

"smooth curve drawn to indicate the pattern of loudness . . . regardless of the fundamental frequency,"[10] was determined by measuring the central tendency of the respective loudness spectrum graphs thus determining the mean for each experimental cane setting. The spectrum envelope provided a visual means for averaging and comparing the qualities of the reeds from each experimental category.

Anticipated Results

Two principal results were anticipated. One was the publication of a systematic study of the gouging and shaping of oboe cane. A thorough description of the materials and processes and a definition of the concepts and principles involved in these processes were included. The clarification of these processes is preliminary to a more thorough understanding of the entire reedmaking process. The second anticipated result was the illustration and subsequent definition of the interaction between these preliminary stages of reedmaking and the apparent tonal quality of the finished product. This study attempted to clarify some basic acoustical concepts and provide specific information regarding the oboe reed mechanism. John Backus, in his text, The Acoustical Foundations of Music, notes that woodwind instrument reeds have a "very pronounced effect on the quality of tone produced by the instrument, . . . but that a great deal more investigation is necessary before we understand reed behavior."[11]

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[10] Ibid., p. 372.

[11] John Backus, The Acoustical Foundations of Music (2nd ed.; New York: W. W. Norton and Company, Inc., 1977), pp. 264-67.

Significance

The significance of this study lies in the fact that it provides clarification and documentation to what has historically been a rather empirical craft. The research is one of the more thorough, systematic studies relating specifically to the processes of gouging and shaping oboe reed cane. The function and procedures of the oboe reedmaker are analogous to that of the organ pipe voicer who "works on the basis of previous experience, there being at present no scientific foundation on which to base the process."[12] The amount of information regarding those specific aspects of gouging and shaping found in any literature pertaining to the oboe or oboe reedmaking is minimal and non-specific. One comprehensive study of these processes is found in the treatise authored by Robert Sprenkle and David Ledet, The Art of Oboe Playing. Even this work testifies, however, to the empirical nature in which these techniques have been viewed in the past. "Some practice, experimentation, and testing of the results will help to set the 'feel' of the machine for the reedmaker . . . After the reedmaker has had enough experience to form a basis for judgment, the trial and error method is valuable from an experimental standpoint."[13] This study serves as one of the first published handbooks or guides specifically involving the oboe gouging and shaping processes.

The experimentation regarding pitch and tone quality represents one of the first collections of data utilizing scientific methods in

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[12] Ibid., p. 251.

[13] Sprenkle and Ledet, The Art of Oboe Playing, p. 62.

an attempt to define the relationship between cane dimensions and tonal quality of the oboe.

The understanding and application of the information resulting from this study provide a more substantial command of the craft of oboe reedmaking and a significant contribution to the pedagogy and performance of the oboe.

CHAPTER II

GOUGE AND SHAPE

The gouge and shape of oboe reed cane are the intermediate stages of the process through which cane must pass from its origin as a stalk of Arundo donax cane to its completion as a finished oboe reed. The gouging and shaping of oboe cane are preliminary to the binding of the cane on the staple and the final step of scraping the reed to play.

Selection of Cane

Oboe reeds are made from sections of Arundo donax cane, which is a bamboo-like grass which grows in tall stalks which are somewhat tubular in shape. The cane used specifically for oboe reed production generally ranges from 9.5 to 11.25 mm in diameter, with the average useable diameter being 10.5 mm. The length of the sections of the tube to be used depends upon the distance that occurs between nodes on the cane. A node is a point from which leafy sheaths project from the stalk; nodes appear periodically along the length of the stalk. At each node, a marked irregularity like a swelling on the surface of the stalk occurs and for that reason cannot be used in reed production. The stalks of cane may grow from six up to twenty feet in height, but only the length of stalk between nodes is utilized. Since nodes occur closer together at the top of the stalk, shorter sections are generally

from the upper portions while longer sections come from lower portions of the stalks.

"Thorough, careful selection of cane is . . . of utmost importance, because cane is useable only within limits."[1] The cane stalks, although appearing to be tubular, rarely conform to a true radius and seldom grow straight along the entire length of the stalk. Preparation of the cane begins by splitting the tube into three lengthwise strips with an arrow splitter. The tubular cane with the bark side out has a curved surface which conforms to the outside diameter of the stalk. Although the average diameter is approximately 10.5 mm, when viewed in cross-section, it appears that cane often grows in an elliptical or tear-drop shape. Splitting the cane into the three strips can result in each of the strips having a different radius. The arrow may be aligned so as to achieve the proper useable radius in the maximum number of strips.

When the cane has been properly split, each useable strip must be cut to the proper length. Before cutting, it is important to gauge the straightness of the cane in two ways: along the bark side of the cane and along its length. The degree of straightness of the bark side can be judged by placing the cane bark side down on a flat surface such as a table top or a flat knife blade and inspecting the cane to make certain that it is parallel to the flat surface and does not bow upward at its ends or middle. The straightness of the cane along its length must be parallel to the length of the gouger bed and not warped or curved. Any cane which does not conform to these criteria must be discarded. When the most desirable portions of the cane strips have been

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[1] Sprenkle and Ledet, The Art of Oboe Playing, p. 48.

selected, the cane may be guillotined to the appropriate length. Actual length of the guillotined strips is variable and is primarily determined by the length of each individual gouger bed, with average length being 7.5 cm.

Pregouging

Split and guillotined cane is next pregouged. This is the process of paring the cane which prevents the ungouged cane from protruding excessively from the top or sides of the gouger bed. Pregouging may be accomplished by the use of a plane and plane board, a filiere or die, or may be done by hand with a knife. The plane board is a board with a track in which is set a bed similar to that on the gouging machine. As the plane is pushed across the track, it removes all excess cane protruding from the bed. The filiere is also similar to the bed of a gouger with a knife-edge blade mounted on the end of the bed. The cane is placed in the bed and pushed past the knife-edge, which removes cane from the top and sides of the cane strip. The process of pregouging saves wear and tear on the gouging apparatus by eliminating extraneous cane. Pregouging provides for a more consistent gouge contour. Cane which protrudes excessively from a gouger bed can be distorted in shape by the pressure exerted by the gouger blade and guides. Pregouged cane also allows the gouger blade to come into contact only with the centermost portion of the cane strip which will become most critical to the reedmaking process. Cane with sides excessive in size also has a tendency to get snagged by extreme sides of the gouger blade which can shred or pull fibers along the sides of the cane or may force the cane to ride up and out of position in the gouger bed. Changing position of the cane

in the gouger bed can change shape and symmetry of the gouge contour and may render the cane useless.

Gouging Apparatus

The gouging machine is a type of sophisticated plane which must be able to produce cane to dimensions with tolerances of less than one hundredth of a millimeter. The fundamental purpose of the gouger is to create a piece of cane which, when viewed in cross-section, is thickest in the middle and gradually thins to either side. A gouging machine has a curved blade which gouges a furrow along the inside of the cane on a radius roughly similar to the outside (bark side) radius of the reed cane. The desired effect of having gouged cane with a thicker center and a tapering to thinner sides is produced by the superimposition of these two slightly different radii. In general, the radius of the inner gouge contour is slightly larger than the natural radius of the bark of the cane. It is the relationship between these two radii which determines the strength or weakness of the gouge, the thickness of the cane at any point along the curve, and the rate of tapering; this relationship is also important to the resultant quality of the gouge, the amount and type of scraping which must later be done, and ultimately the playing quality of the reed.

The gouger apparatus features a stationary bed which is fastened to the base of the machine. The bed is a rectangular block of metal which has on its upper surface a furrow whose diameter roughly matches the outside diameter of the cane, approximately 10.5 mm. The cane is placed bark side down in this furrow. Attached to each end of the gouger bed are spring loaded clamp devices, or cane hooks, which secure

the cane to the bed. The hooks are mounted on axles permitting the hooks to pivot out of the way as the gouger carriage passes over the cane during the gouging process.

Another feature of the gouging machine is the carriage or slide-block on which is placed the critical scraping mechanism of the machine, the blade. The carriage slides laterally along a bar or rod and may also be pivoted vertically by using its mounting on the rod as a hinge, allowing the blade mechanism to be swung toward or away from the cane surface. The slide rod is supported by two posts, one at each end, attached to the gouger's base.

Attached to the carriage is a ball-bearing roller wheel. When the carriage reaches the horizontal position, parallel to the gouger bed, the roller wheel comes to rest on the roller bar. The setting of the wheel and roller bar prevents the carriage and blade mechanism from striking the gouger bed, which might damage the gouger blade. When properly positioned, this setting of the wheel and roller bar allows for the appropriate thickness of the gouged cane by limiting the descent of the carriage. Some typical methods of regulating the depth of the cut involve changing the height of the roller bar or changing the position of the roller wheel. A simple and frequently used method is one in which the roller bar is comprised of two triangular wedges. Sliding the lower wedge in or out forces the upper wedge up or down respectively. A large set screw is placed between the wedges and locks them in place when properly aligned. Other methods involve changing the position of the roller wheel. The wheel mechanism may be threaded, allowing it to be screwed either up or down, or the

wheel may be hinged so that it will swing when the hinge is loose and lock into place when the hinge is tight.

Blade

The blade (a knife with a rounded scraping contour) is one of the most critical components of the gouger. Historically, the original gougers were merely hand scrapers with curved blades. "Formerly this was done entirely by hand and eye, but since the mid-19th century a small plane or 'router' with a curved blade sliding on steel guides has been employed, and this does the work very easily and accurately."[2] The modern gouging apparatus is based on the principles of the plane in which a cutting blade is set between two guides. The blade protrudes slightly from the guides providing a means for controlled and consistent removal of cane. The gouger blade's scraping edge is ground to a curve. The guides between which the blade is set are also curved. The relationship between these two curved surfaces basically determines the gouge contour of the cane. The shape of the blade and its relationship particularly with the front guide determine such things as: the amount of blade exposed to the cane, the parts of the blade exposed, the size and shape of the cane chip removed, and the depth of the cut. One other critical aspect regarding the blade is the angle at which the blade is set in the machine. Most blades are mounted on the carriage approximately at a 45 degree angle. Due to the phenomenon of parallax, the precise angle at which the blade is set becomes important since the shape of the blade will appear to change due to its

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[2] Philip Bate, The Oboe (2nd ed.; London: Ernest Benn Limited, 1962), p. 12.

having been displaced at the 45 degree setting (see Figure 1). The actual angle at which the blade is set varies slightly, depending on the design of the particular machine.

Technical Description of the Reynolds and Michel Gouging Machines[3]

The machine from Claude F. Reynolds and Son, Inc. (Figure 2) was manufactured by Gordon Reynolds. The body is primarily cast from aluminum and the remaining parts are steel. The base is rather large to accommodate the sturdy components of the gouger mechanism along with the guillotine, which is mounted on the left side of the base. The gouger bed and two slide bar posts are bolted to the base from underneath. The position of the bed and accompanying roller bar assembly is adjustable but requires the loosening of the mounting bolts (from below). The height of the roller bar is constant. The roller bar is located on the front side of the machine with the bed immediately behind. To the rear of the bed is the slide rod or slide bar mechanism mounted at each end by the two posts. The carriage assembly rides on the slide bar.

On the front face of the carriage assembly is the roller wheel. The position of the roller wheel is adjustable and pivots on a 3/16 in. hold down screw. When the hold down screw is fully tight, the wheel is held in place. The positioning of the roller wheel is aided by an adjusting screw immediately above the roller wheel. The adjusting screw limits the swinging motion of the wheel and functions to regulate the height or position of the wheel. Since the roller bar is

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[3]These two machines were selected on the basis of their exhibiting the two contrasting gouge techniques and have additional features not found on other available machines such as the Graf machine.

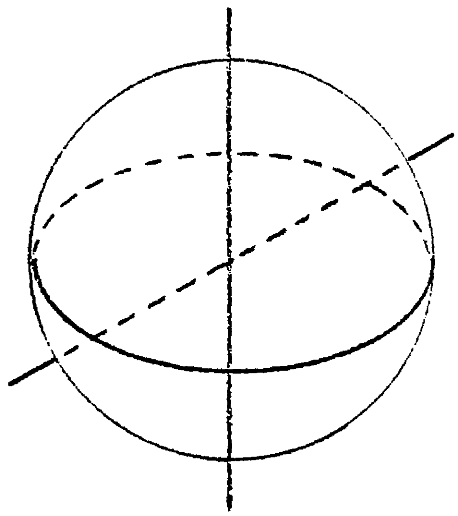

Figure 1. Illustration of the Effect of Parallax.

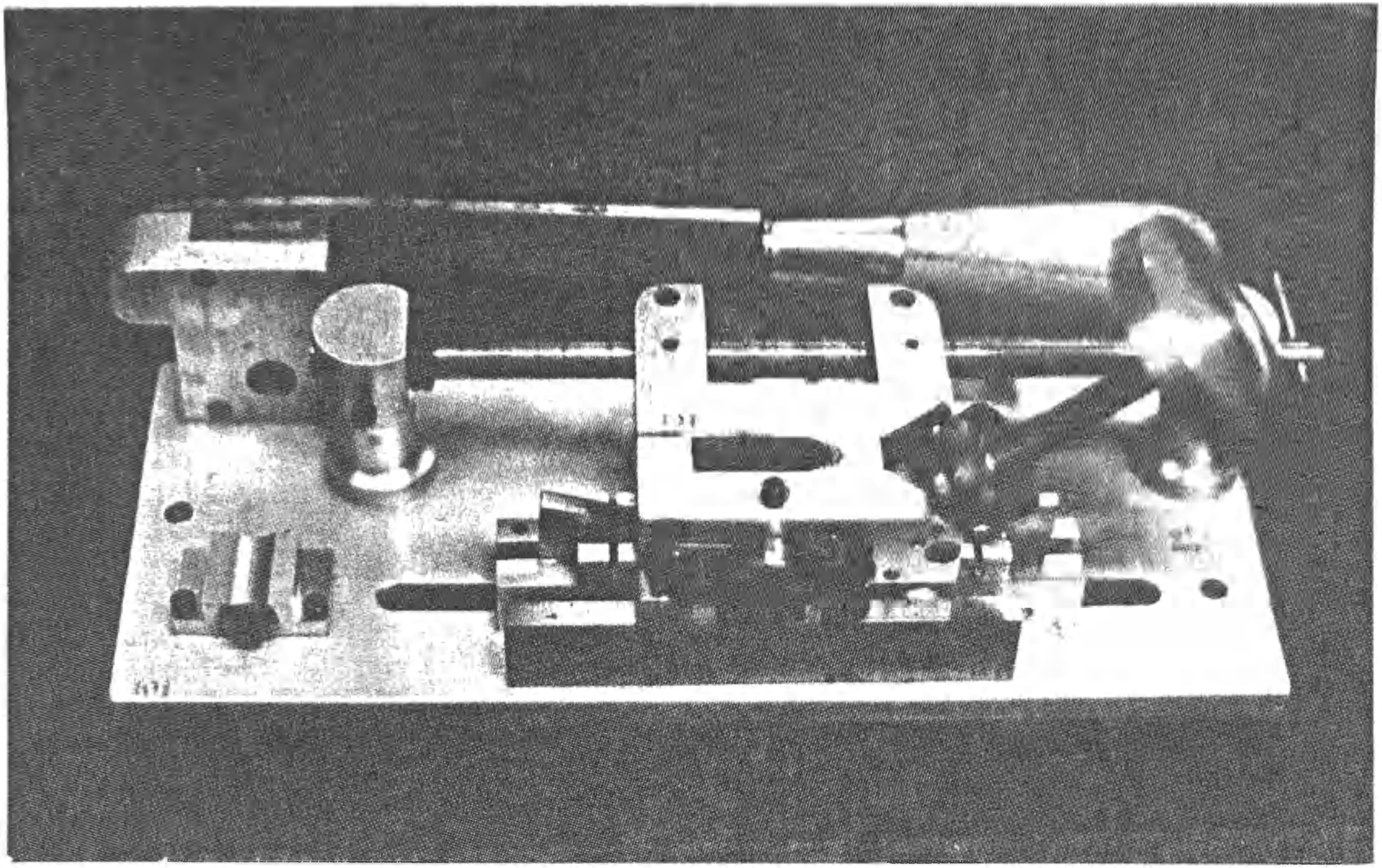

Figure 2. Gouging Machine by Claude F. Reynolds and Son, Inc.

stationary, it is the position of the roller wheel which limits the descent of the carriage towards the gouger bed.

The primary function of the carriage is to carry the blade and hold it in position during the gouging process. The blade of this machine is placed in the blade cavity near the center of the carriage or slide block. The blade is secured to the carriage by two set screws. One is placed through a slot in the blade and into the carriage at a 45 degree angle. The second set screw is horizontal and serves to pin the blade against the rear vertical wall of the blade cavity. When set firmly against this wall, the blade remains vertical and is automatically centered with respect to the guides. This feature is designed to eliminate any variability in the alignment of the gouger blade with the guides. The only adjustment actually required in this system is the regulation of the amount of blade exposed past guides which determines the thickness of the chip during gouging.

The alignment of the centerpoints of the blade and guide with the centerpoint of the bed is accomplished by the positioning of the slide bar or rod. Reynolds mounts the slide bar to the two posts by means of eccentric bearings. On the right end of the slide bar is a handle which may be rotated up or down several degrees. Because of the action of the eccentric bearings, any rotation of the bar will change the position of the bar and result in a change in the alignment of the carriage over the bed. This feature substitutes for the lack of lateral movement of the blade when the blade is secured in the carriage.

The Michel machine (Figure 3) was obtained through Mr. Robert de Gourdon of the Lorée firm in Paris, France. The maker is M. Kunibert Michel. The base measures 20 cm x 10 cm and is cast from aluminum.

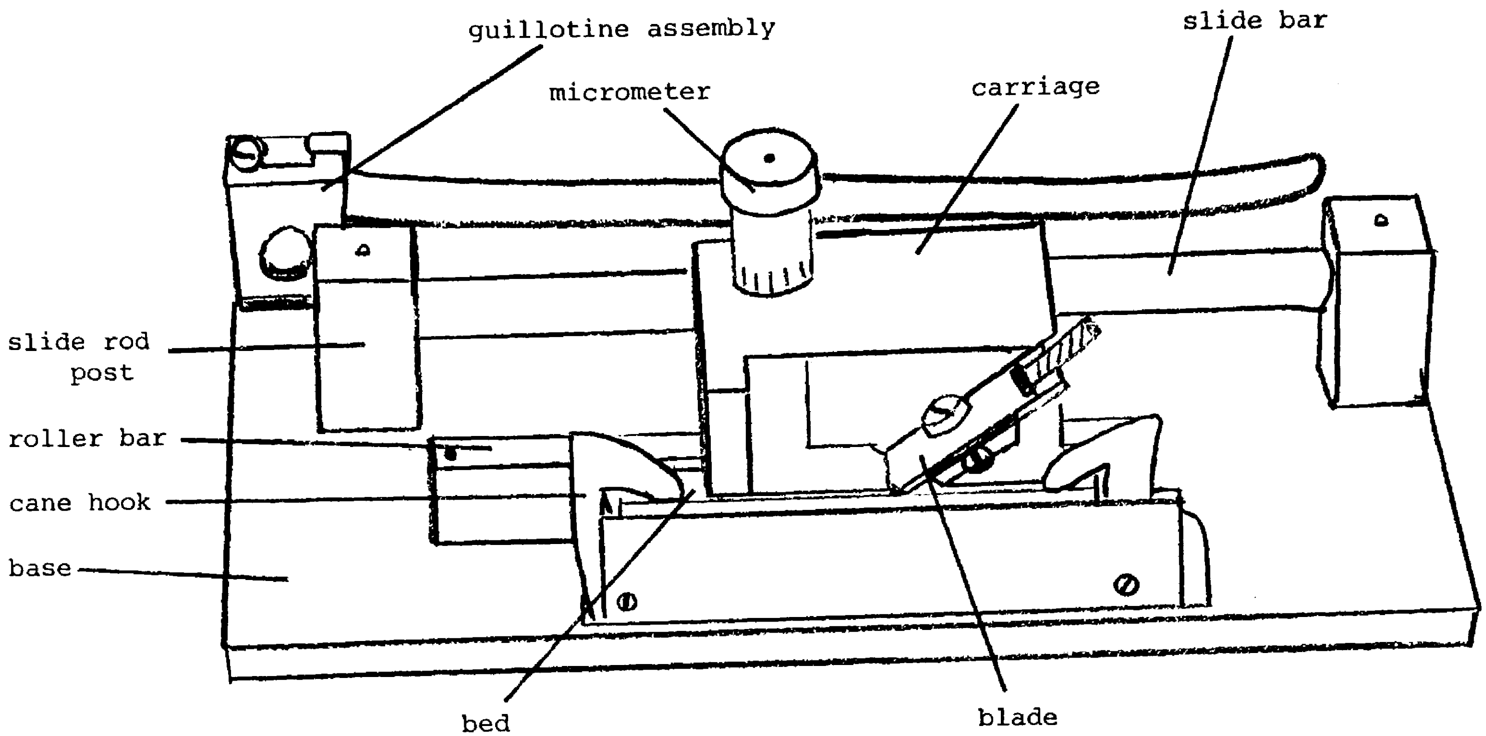

Figure 3. Overlay for Part Identification

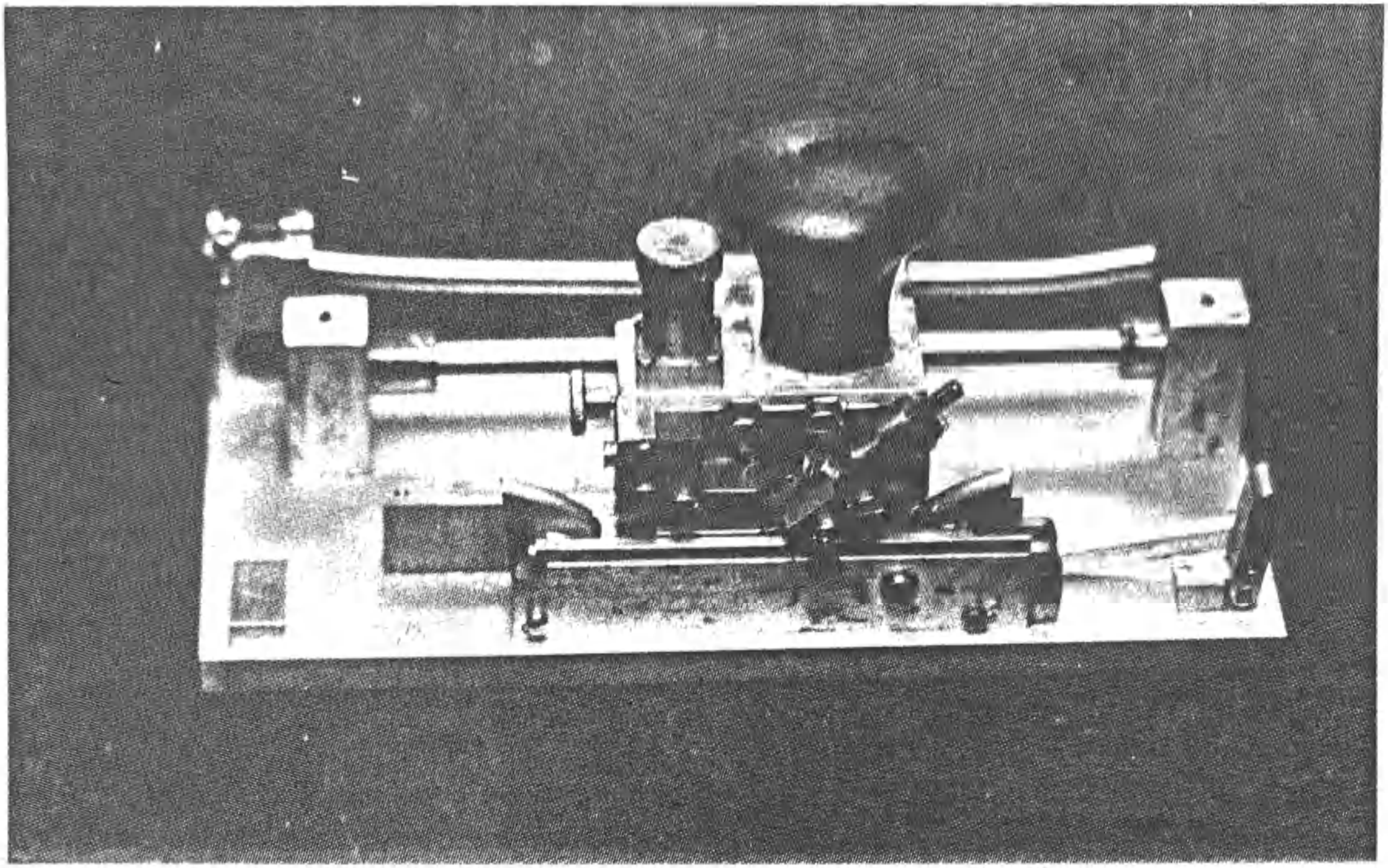

Figure 3. Gouging Machine by M. Kunibert Michel.

The main body of the machine (the bed, guillotine, and carriage assembly) is made from brass. Mounted directly on the base are the two slide rod posts, guillotine assembly, and the bed and roller bar assembly. These parts are bolted to the base from the underside.

The bed and roller bar assembly is adjustable and may be positioned by loosening the mounting bolts. The height of the roller bar is adjustable by the positioning of set screws at each end of the roller bar. These two set screws contact the gouger base and regulate the height and horizontal positioning of the roller bar. At the time of this writing, the height of the bar is set at 14 mm. The gouger bed is on the immediate front side of the machine with the roller bar assembly immediately to the rear. The bed's furrow has a diameter of 10.5 mm and also utilizes the two spring-loaded cane hooks. The cane stop on the right hand side of the bed is a spring-loaded piston which clamps the cane into the bed as it contracts. The length of the totally contracted bed is 75 mm but expands 5 additional millimeters. The cane is cut by the guillotine to a length of 76 mm allowing one millimeter overhang of cane, allowing the clamp mechanism to function properly.

The gouging blade of the Michel machine approximates a radius of 4.36 mm at its peak and is positioned on the outside front of the carriage assembly. The blade is secured to the carriage at a 40 degree angle by four set screws. One screw is placed through a slot in the blade and into the carriage, locking the blade in place. Two other set screws are placed horizontally and can be seen on the front side of the carriage, butting a small brass block against the outside of the gouger blade. The fourth screw, also horizontal, is on the rear

side of the carriage, driven against the back side of the gouger blade to balance the action of the other two. These three set screws maintain the blade's lateral position and serve to center the peak of the blade with the centers of the guide and gouger bed. The blade is set between the two guides which have a diameter of 11.75 mm.

A feature of this particular machine is the addition of a micrometer, graduated in metric units, to the carriage. The roller wheel is connected directly to the micrometer. A rotation of the micrometer changes the position of the roller wheel, which in turn regulates the cutting depth of the gouge. The micrometer permits minute adjustments to be made in the depth of the cut without having to reposition the blade or readjust other parts of the machine.

Table 1 compares dimensions of machines utilizing two approaches to the gouging process. Note particularly the relationship between the radii of the blades and of the guides in the two machines.

The blade of the Reynolds machine conforms to a radius of 3/16 inch. This is coupled with the front (leading) guide which has a radius of 7/32 inch. The blade's actual radius is slightly smaller than that of the guide, but the blade is positioned at a 45 degree angle. Angling the blade involves the phenomenon of parallax and makes the blade's curve appear to flatten forming a nearly elliptical contour. When sighting along the guides from front to rear, the contour of the edge of a properly positioned blade can be compared against the contour of the guide (see Figure 4). In the case of the Reynolds machine, the two slightly different contours result in the blade protruding in two peaks, one on each side of the centerpoint. The exact centerpoints of the blade and guide appear to coincide.

TABLE 1

GOUGING MACHINE STATISTICS

	Reynolds	Michel
Base:	10 in. x 4 in. (25.4 cm x 10.16 cm)	20 cm x 10 cm
Bed Length:	2 31/32 in. (7.54 cm)	7.5 cm
Bed Diameter:	7/16 in. (11.11 mm)	10.5 cm
Guillotine Length:	2 15/16 in. (7.46 cm)	7.6 cm
Guide Diameter:	7/16 in. (11.11 mm)	11.75 mm
Blade Radius:	3/16 in. (4.76 mm)	4.36 mm
Blade Angle:	45°	40°

NOTE: The Reynolds gouging machine is built to standards of measurement in inches. Conversion provided for comparison.

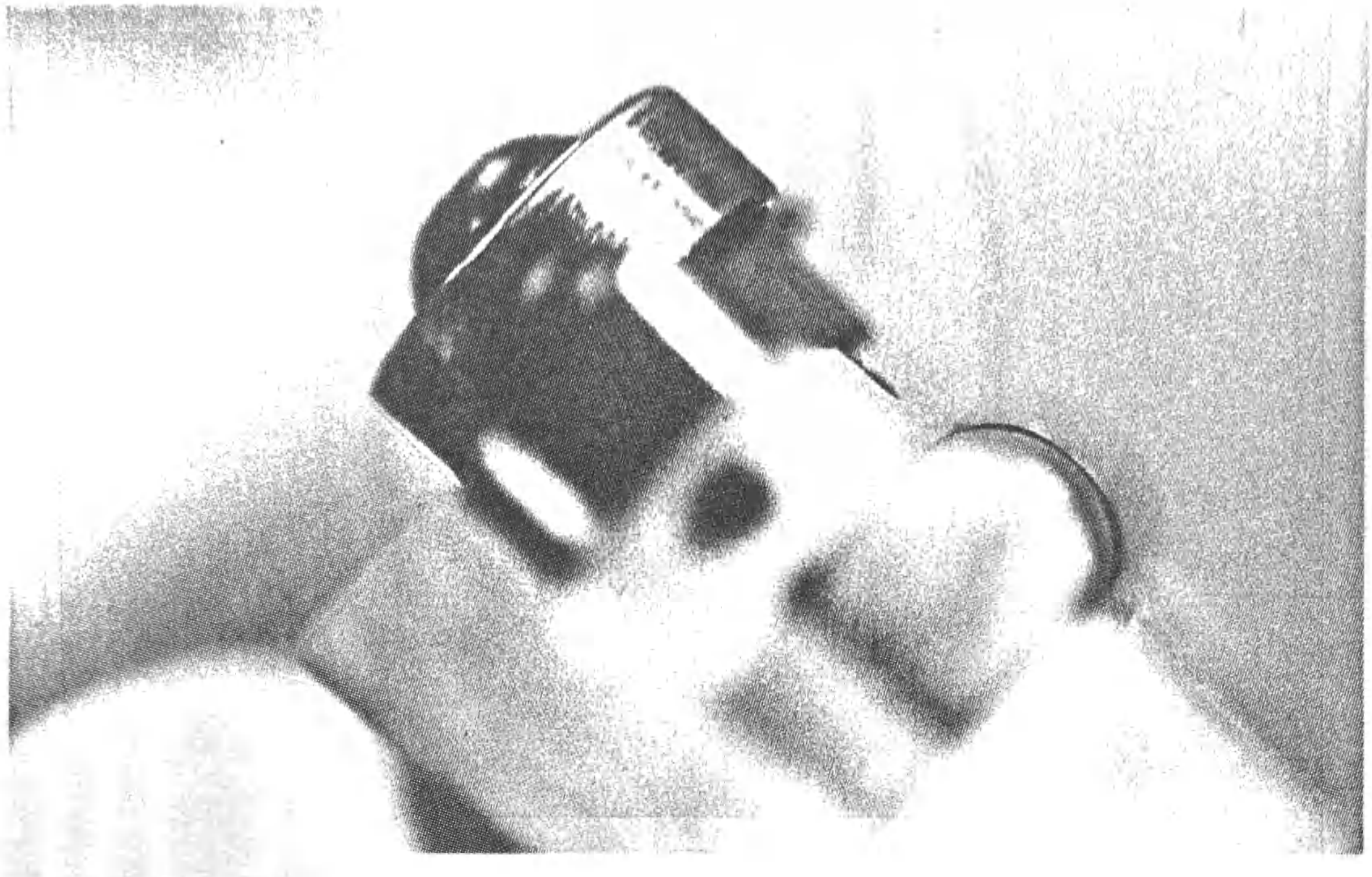

Figure 4. Comparison of Guide and Blade Contours in Reynolds Gouging Machine.

This positioning and relationship between the guide and blade are symmetrical. Therefore, the gouge contours from the centerpoint to each side should be identical. This relationship requires that the centerpoints of the blade and guide also coincide with the center of the gouger bed. This symmetrical structuring of the machine's components eliminates any necessity of reversing cane in the gouger bed and gouging in two directions.

The Michel machine illustrates the opposite approach in terms of the relationship between the guide and blade. The diameter of these guides measures 11.75 mm, which is equivalent to a radius of 5.87 mm. The blade presents some difficulty in measuring since its shape more resembles a parabola than a true radius. The parabola is slightly peaked and has a continuously changing radius. The most critical parameter is the radius at the peak of the blade which in this case measures approximately 4.35 mm. The radius of this blade is notably smaller than that of the guide. When positioned in the carriage, the blade is held at a 40 degree angle, even more acute than Reynolds' design. By parallax, the sharp peak of the blade is softened and, when sighted along the guides, the blade appears to conform more closely to a true radius. The curves of the blade and guide appear quite similar but not identical: the contour of the blade appears smaller than the contour of the guides (see Figure 5).

The technique of gouging which results from this particular relationship between the dimensions of the blade and guide has three basic premises: (1) the blade has a smaller radius than the radius of the guide; (2) the axis of the blade should be slightly offset or displaced from centerpoint producing an asymmetrical gouge contour; and

Figure 5. Comparison of Guide and Blade Contours in Michel Gouging Machine.

(3) the cane should be reversed in the gouger bed and gouged in both directions. This approach to gouging was designed to minimize the difficulty and to maximize the consistency of the gouging process. When properly applied, this technique insures a symmetrical gouge contour and a graduation of thickness which is identical from the middle to each of the two sides. The basic principle is to apply the same part of the same blade to the areas of the cane which need to be identical.

Displacing the axis of a blade causes the blade to dig more along the side toward which the blade is offset. Less is then removed from the other side of the cane creating an asymmetrical gouge contour. However, by reversing the direction of the cane in the bed, the blade will dig the same contour as on the opposite side of the cane. As a result only one side of the blade will be critical to the gouging process. The blade maintains its critical radius only along that one cutting side, from the centerpoint to the blade's edge. It is possible that a blade with a true radius may interfere with the curves cut by the critical cutting portions of the blade. Along the non-critical edge to the center, the curve may be depressed or flattened by grinding away any excess metal. Grinding in this manner then makes the blade asymmetrical in shape from the centerpoint toward each side. The resulting shape is a somewhat skewed parabola. Measurements of a parabola are difficult, but some approximations for illustrative purposes can be made. The ideal gouger blade "is formed to superimpose several different radii along the same general curve."[4]

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[4]Robert Weiner, personal interview. Mr. Weiner, a former student of John Mack, is a noted authority on oboe cane gouging.

The relationship between the radius of the blade and the radius of the guide forms one of the most essential means of comparison between gouging machines. Other aspects should also be considered.

The size of the bed is a limiting factor in the gouging mechanism. The diameter of the bed determines the size cane which can be utilized. Cane used for oboe reedmaking ranges in diameter from 9.5 mm to 11.5 mm. A gouger bed which is too small will prevent the use of larger diameter cane. The larger cane is flatter in shape and when it is gouged, the pressure of the guides and blade will tend to bend the cane to conform to the shape of the gouger bed. Frequently, this results in cracked cane. Cane with a radius too small for the bed will often gouge poorly since the bed cannot adequately support the cane and keep it in one position during the gouging process. Extremely small diameter cane shifts in the bed during gouging producing inconsistent gouge contour. Robert Weiner, an expert in the gouging procedure, has suggested an ideal diameter of the gouger bed of 11.0 mm. This would provide an average size bed which would also serve to accommodate cane of slightly varying diameters.

On the same machine, cane of different radius dimensions will produce different gouge dimensions. The shape of the cane will tend to cause the blade to scrape more cane from some areas than others. Generally, cane of larger diameter will result in thicker sides and less gradation from center to sides than cane of more average dimensions. Smaller diameter cane will tend to have more cane removed along its sides (at the shaper edge) leaving relatively more cane in the center and resulting in a more rapid gradation of thickness toward the sides than would be found in cane of more average dimensions.

The experience of working with the Reynolds and Michel machines has provided an opportunity to observe that the Michel machine, with its smaller diameter bed (10.5 mm), is capable of successfully working cane within the range of 9.5 mm to 11.0 mm in diameter. The Reynolds machine, whose bed is slightly oversized, tends to prefer cane with diameters of 10.5 mm or more. The Reynolds machine accepts cane of the smaller diameters with great reluctance. The type and construction of gouger blade also affects the use of different cane diameters. The curvature and peaks of the blade on each side of the center point indicate that the primary cutting action takes place along the sides of the cane. Cane with small diameter coupled with the lack of support in the overly-large gouger bed will tend to exaggerate this cutting action; consequently, the gouger "eats up" the sides of the cane. Therefore, it can be seen that the type and construction of the gouger blade and its relationship with other components can also act as limiting factors.

Other considerations are the size and shape of the gouger blade. The shape of the blade is of the utmost importance. The primary motive for utilizing the asymmetrical type of blade is to eliminate variability. The motivation for constructing the asymmetrical blade stems from the fact that it is difficult, if not impossible, to grind by hand and eye a perfectly symmetrical curve on a piece of metal. Blades may be mechanically tooled through the use of extremely expensive and complicated equipment which is seldom accessible to oboists. One of the few suppliers of gouging apparatus with mechanically reproduced gouger blades is Claude F. Reynolds and Son, Inc. Most machines, when purchased from a reputable dealer, have been adjusted

and are ready to use. However, any subsequent adjustments or alterations must be done by eye and hand. For example, one of the most highly regarded gouging machines available, made by Graf, comes in one of two forms, either completely unassembled, or partially assembled with only parallels set and no guide or blade work done at all. The blade is a blank in the form of a block of tempered steel. This machine can also be purchased from an expert craftsman, such as Hans Moennig in Philadelphia, Paul Covey of Baltimore, or Robert Weiner of Oklahoma City, who then assembles the machine, grinds the blade, regulates the machine's components, and makes the final adjustments in preparation for gouging. However, after the purchase of any machine, all sharpening and adjustments required by a blade must be done by hand and eye. A more detailed comparison of the blade approach and construction in the machines by Reynolds and Michel will serve to illustrate some of the considerations involved in making adjustments to the instrument.

The basic requirement of Reynolds' symmetrical approach is that the blade must conform exactly to the same curve from the centerpoint to each side of the blade. This allows for very little margin of error. The Reynolds' machine functions very well using this approach since the blade can be mechanically ground to produce the precise curve needed. Any adjustments or alterations to suit the requirements of the individual reedmaker must be done by hand. These alterations are certainly possible, but considerable care and patience are required, since any change made on one side of the blade must be exactly duplicated on the other to maintain a true symmetrical radius. The curve of the blade and its relation to the guide from the center to each side

must be an exact mirror image to insure the same contour and gradation of thickness on each side of the gouged cane.

The concept of using the asymmetrical type of blade construction as in the Michel machine was perhaps inspired by the difficulty of the above approach. Robert Weiner explains: "The only reason to gouge in this way is that it is easier. When the cane is reversed in the bed, both sides are gouged exactly the same. The 'one way' gouge is acceptable, but it is very difficult to grind a perfectly symmetrical contour. This asymmetrical way, only one half of the blade is worked and it hits both sides of the cane."[5] In practice, Mr. Weiner's comments seem valid. It is less complicated to grind the appropriate cutting edge on only one side of the blade. The shape of that curve is basically determined by the shape of the guide, which can serve as a pattern or kind of template. The blade is ground to a shape determined by the amount and shape of the blade which is exposed over the guides.

In the Michel machine, the blade's lateral position, the vertical position, and the axial position are all variable. The relationship between these three aspects is extremely complex and sensitive. A slight alteration of the blade's position has a distinct effect upon the entire relationship. Again, the main concern is with the amount and shape of the showing portions of the blade. The blade should peak at the center, but some experimentation proves that the peak can be made to show over the guide in a more sharp peak or a more soft curve. The amount of blade showing around the sides of the curve is also variable. The blade's relation to vertical or axial position is another important factor to consider. There is no way to set the blade in this type of

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[5] _Ibid._

carriage which will insure an exact vertical positioning of the axis of the blade. A displacement of the axis from the vertical position will create a completely new relationship between the skewed curve of the blade and the true curve of the guides. These factors, of course, directly influence the corresponding shape of the gouge contour of the cane. The contour of the gouged cane surface is determined by the shape of the blade with respect to the shape of the guides and also by the position of that blade against the guides. Note in Figure 6 the asymmetrical blade positioning and the resulting radius (R_1) of the gouge on the single direction of the gouge stroke. The radius (R_1) of that gouge contour is less than the radius of both the guide and cane. To produce this effect, the gouger blade must have a correspondingly small radius and the blade's axis must therefore be placed slightly off center (D = distance the blade's axis is displaced). Any change in the value of D or R will produce a corresponding change in the gouge contour of the cane. Increasing D will result in cane of roughly the same thickness but a different distribution producing cane with relatively thinner sides and a thicker center.

Another adjustment is one in which the value of the radius (R) is altered. When the cane is reversed in the bed and gouged in the opposite direction, it produces another radius (R_2). The convergence or divergence of these radii illustrates the concept of stronger and weaker (not to be confused with thicker and thinner) gouge contours. A strong gouge contour refers to one in which the distribution of the cane is such that the rate of gradation is slow from the middle radiating out to the sides. A weak gouge is one in which the cane gradates more quickly from the center to the sides. Increasing the

displacement of the blade's axis produces a weaker gouge. As a general guide, the average rate of taper would show a deviation from center to rib of .05 mm and center to shaper edge of .13 mm. Any less than .04 mm from center to rib can be considered weak.[6] Likewise, when the value of the radius is altered, a corresponding change occurs on the gouge contour: in general, the larger the radius of the blade, the stronger the gouge; correspondingly, the smaller the radius, the weaker the gouge. This relationship must always be considered in conjunction with the displacement of the blade. A gouge contour resulting from the over-displacement of the blade forms a ridge or rib in the center of the cane. The aperture of a reed made from this cane would be unacceptable because of its poor closure with the tendency to close first in the middle. This rib could be corrected in two ways: (1) by reducing the displacement and bringing the peak of the blade closer to center which would cause a convergence of the two radii, or (2) grinding the peak of the blade down to increase the radius of the gouge contours.

To summarize, while Reynolds' approach to the blade may create difficulties in grinding and may be more sensitive to any changes in the blade's radius, the positioning of the blade is made nearly foolproof. While it may be easier to grind a blade for use in an asymmetrical system, such as Michel, its setting is extremely se-sitive, must be done by eye, and basically relies of the trial and error method.

Two methods of regulating the depth of the gouge are illustrated in the Reynolds and Michel machines. This is an important consideration

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[6] Ibid.

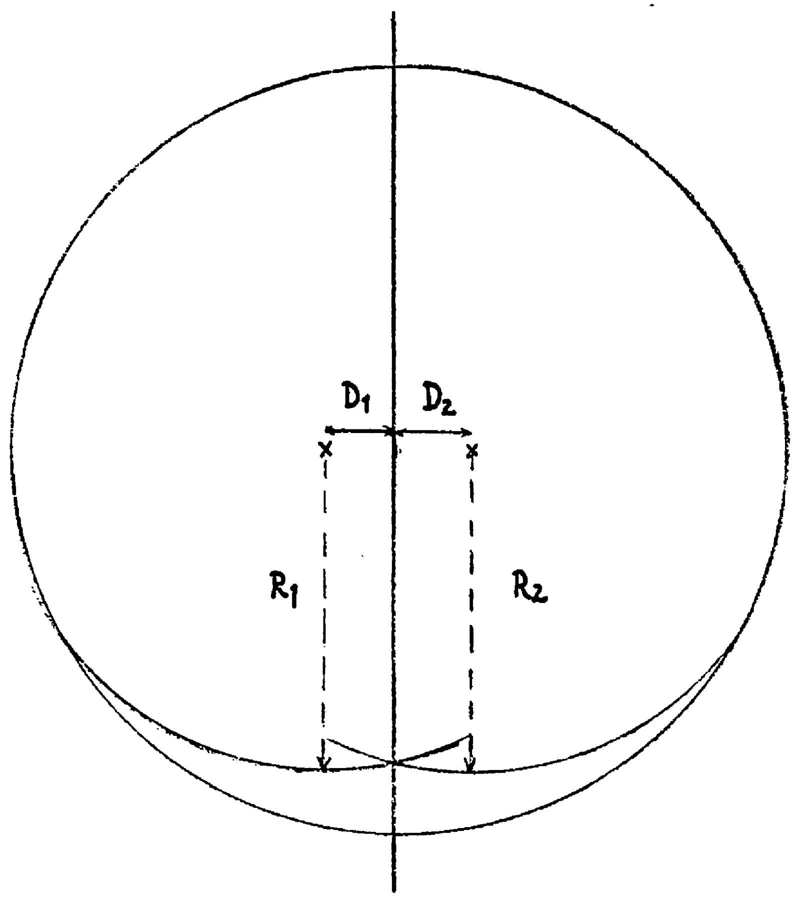

Figure 6. Asymmetrical Blade - Displacement of Radius.

since alterations in the depth of the cut are among the most frequent adjustments made. The most precise method is found on the Michel machine (see Figure 7). This system regulates the descent of the carriage by mounting the roller wheel directly to a micrometer set into the carriage. One can determine precisely how much change is made in the depth by using the graduations on the micrometer.

The hinged roller wheel assembly is found on Reynold's machine (see Figure 8). While it functions satisfactorily, one can never be certain how much a change in depth occurs with a change of position of the wheel. One distinct problem in this case is that the cane stops, positioned at each end of the gouger bed, approach the thickness of the gouged cane so closely that it is not unlikely that lowering the wheel too much at once could cause the blade to strike the cane stops, thus damaging the blade. The same problem is inherent in the wedge-design roller bar assembly if the bars are not marked with some type of graduation as found in the Graf machines.

Tracking refers to the way in which the carriage, guide, and blade assembly travel along the gouger bed and the center of the guides over the bed. It is generally regarded as desirable to have the carriage assembly travel parallel to the gouger bed and to have the center of the guides coincide with the center of the gouger bed. Therefore, when gouging cane the blade will "track" down the center of the cane; the chips are consequently scraped from the center of the cane throughout the gouging process.

There are several methods used to achieve a centering of the tracking of the gouger. One involves the positioning of the blade

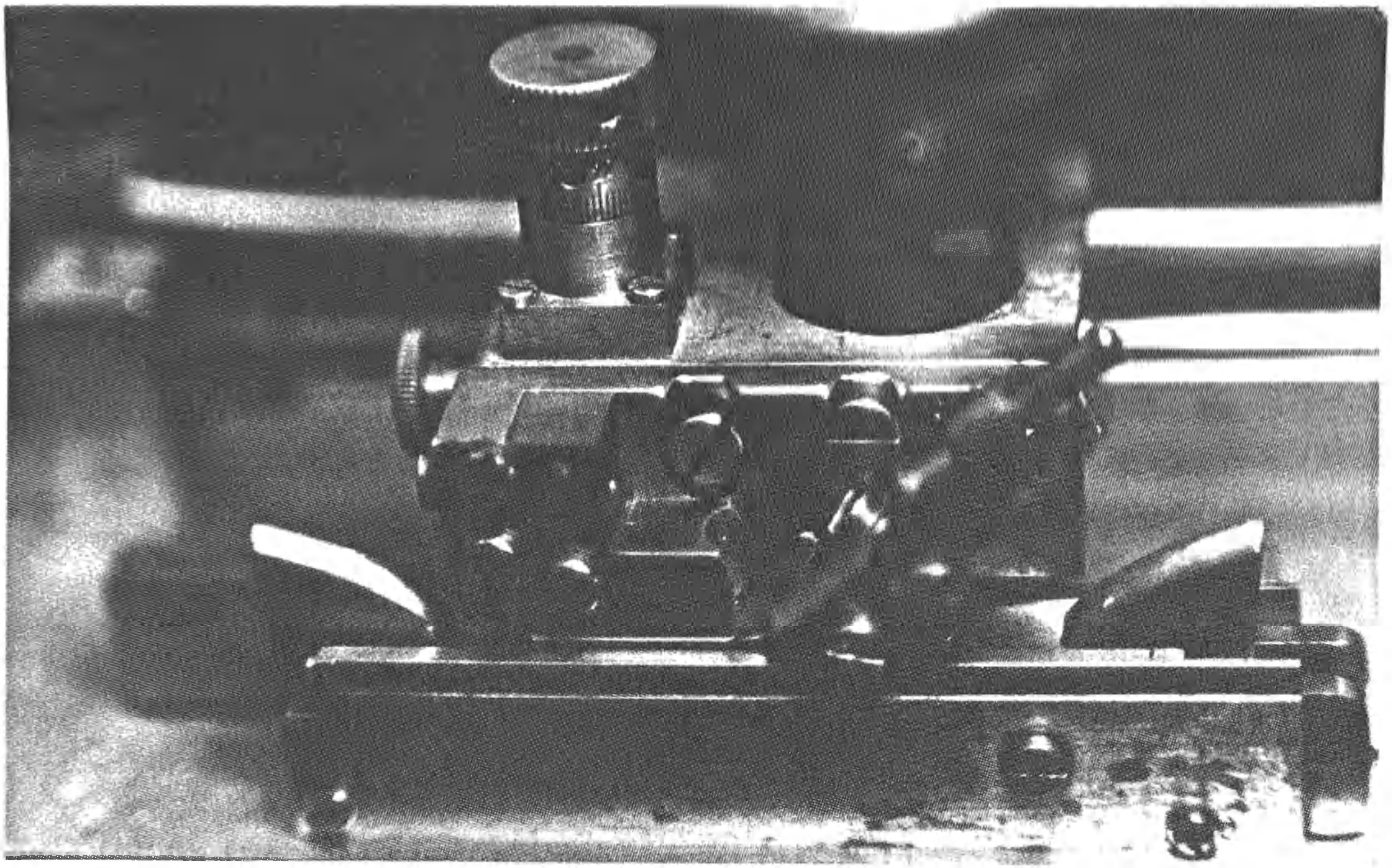

Figure 7. Carriage Assembly and Micrometer of Michel Gouging Machine.

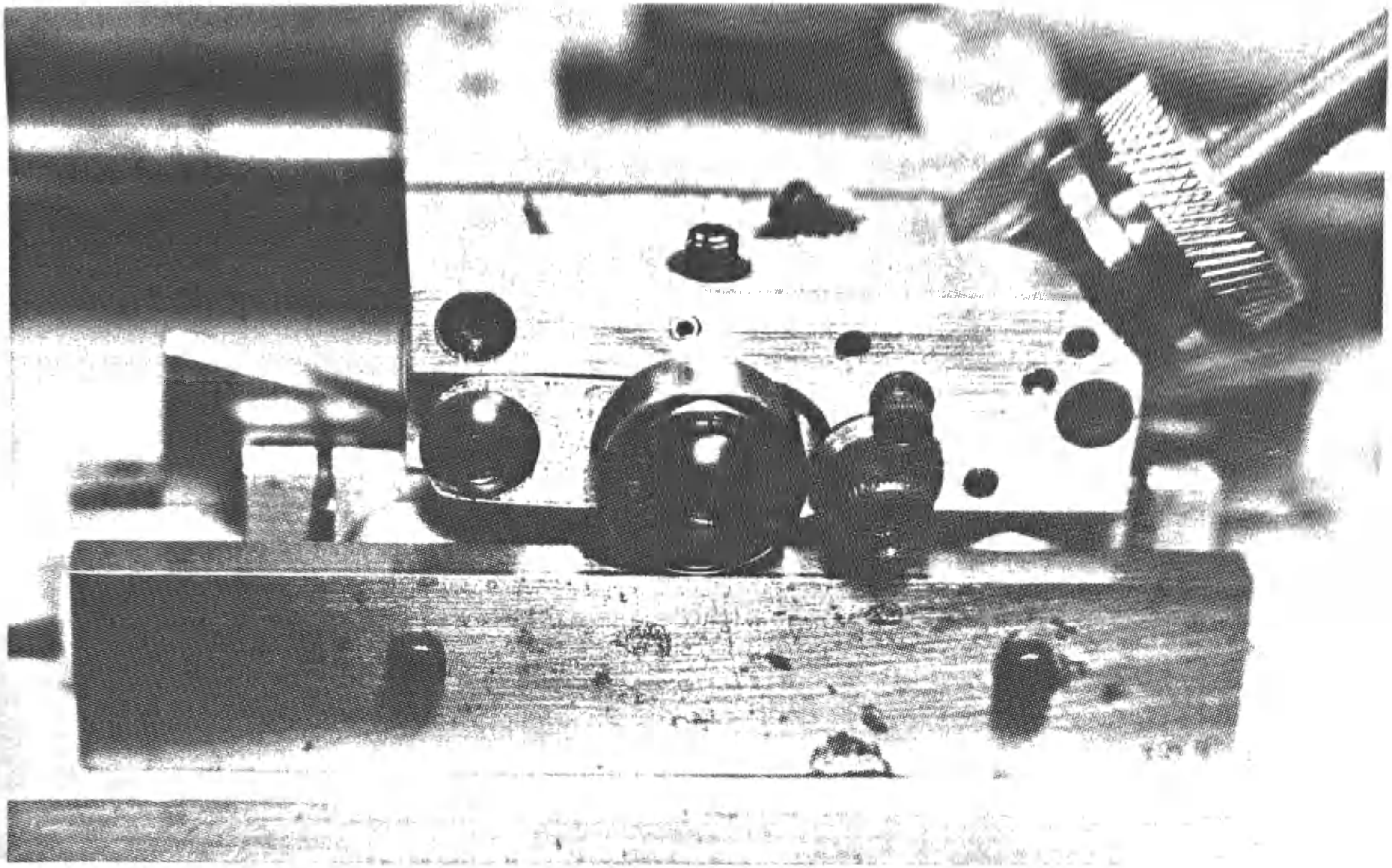

Figure 8. Hinged Roller Wheel Assembly on Reynolds Gouging Machine.

(as in the Michel machine). The blade's lateral position determines its position with respect to the center. This position is regulated by the set screws which secure the blade to the carriage. The second method also involves the positioning of the blade. As opposed to moving the blade in the carriage as noted above, the position of the entire carriage is shifted. This approach (as utilized by Reynolds) requires the use of eccentric bearings in the connection of the carriage and slide rod assembly to the support posts. This system is quite simple and eliminates any need to change the position of the blade within the carriage. A third method of centering the tracking of the carriage to the bed involves the shifting of the gouger bed. The importance of maintaining the parallel between the slide rod and the gouger bed cannot be overemphasized. This is perhaps the least desirable method and should be used only as a last resort. It is nearly impossible to determine and set this parallel by eye. If adjustment is necessary, it may be made with the aid of an Adjustable Parallel tool. Although it is generally preferable to conform to this parallel, some deviations can be found. "In his latest experiments, Dandois is gouging a furrow that is .56 mm at the center tapering to .69 mm at each end (not side) of the piece of cane. Booth (Solo Oboe, National Symphony Orchestra, Wellington, New Zealand) gouges a furrow that tapers from .56 mm in the center to .58 mm on each end."[7] This gouge is achieved by displacing the bed slightly off parallel. In this way, the gouger blade tracks from one corner toward the opposite corner crossing centerpoint only at the midpoint of the bed. The cane is reversed in the bed and gouged. The result is an X-shaped gouge whose

[7]Sprenkle and Ledet, The Art of Oboe Playing, p. 51.

track centers only at the midpoint of the bed, causing the deepest cut (and smallest center measurement) in the center of the cane where the center tracks coincide and a gradual thickening toward each end.

Setting Up Gouging Machine

The first step of setting up a gouging machine involves setting the parallels. The first and most important of these parallel relationships is the aligning of the slide rod with the gouger bed. The position of the bed may be adjusted by loosening the mounting bolts and, using the Adjustable Parallel, moving the bed so that the center line of the bed is parallel to the slide rod assembly. Another aspect which should be considered in setting the parallels is the alignment of the guides with respect to the bed. The center point of the guides should coincide with the center line of the bed. This is particularly applicable to the Reynolds' machine which has a variable setting for this aspect. In the printed instructions provided with the purchase of the machine, Mr. Gordon Reynolds describes the procedure. After the blade is removed and the roller wheel raised to its limit,

> . . . then the guides (the rounded steel pieces which rest in the cane) can be lowered into the bed. By holding back the hooks, you can sight along the bed from the end and determine whether the guides seem to be coming down in the center. If they do not, then you should move the slide-block from one side to the other by rotating the slide bar, which is mounted on eccentric bearings. As you can see, the slide-bar is supported by two posts. Each post has one set-screw which fits the 3/32 allen wrench. After loosening each set-screw, you can rotate the slide-rod by means of a bar which is inserted through one end. A slight rotation of the slide-bar will move the slide-block to the right or left, as you sight down the bed from the end.

One other cause of displacement of the parallel would be the wear after long periods of use on the bearings which connect the carriage to the slide rod. If the bearings are excessively worn and the carriage will

not remain in position, "a slight tightening of the adjusting screws will clamp together the split ends of the slide-block and restore accuracy."[8]

The second step of the setting up procedure is the sharpening of the blade. In sharpening the blade by hand, a listing of necessary equipment includes:

Carborundum brand Hobbycraft (waterproof) Aluminum
Oxide Sandpaper: Ultra fine (600), Super fine (400),
Extra fine (320), Very fine (220)
Emory Cloth #30, #500
Arkansas stones, hard or black
Frictionite stone

For roughing in a blade or making drastic changes in the shape of a blade's radius, the Carborundum Very fine (220) or Extra fine (320) Aluminum Oxide sandpaper is most appropriate. For the final shaping work on a blade, a choice can be made between the hard Arkansas stone or Frictionite stone. To place the final finish on the edge and to set the burr, John Mack recommends the #30 Emory cloth to put a finer polish or "glaze" on the edge.[9] Robert Weiner simply does this finishing work on the fine side of a Frictionite stone, which is a man-made synthetic similar to the natural Black Arkansas stone. The sharpening is done primarily on the bevelled side of the blade. On this side, the honing should be done in a pendulum-like or U-shaped, sweeping motion covering approximately one-half of the blade's radius and then should be shifted to cover the other half of the radius. When sharpening, it is imperative that the bevelled edge be kept as flat to the stone as possible to avoid creating a hump or another bevel,

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[8] Instruction Manual for Reynolds' Gouger from Mr. Gordon Reynolds, Claude F. Reynolds and Son, Inc., Dallas, Feb. 15, 1979, p. 3.

[9] Weiner, personal interview.

immediately behind the leading edge of the blade on the bevelled side. While the flat side can also be honed, it is important to keep this side as flat as possible on the stone to avoid creating another bevel here. This flat side may be honed in almost any direction such as circles or figure eights. The sharpening should always finish on the bevelled side of the blade to put the cutting burr on the edge. If the blade does not cut the cane, the burr may be placed too far over by grinding too much or with too coarse a material on the bevelled side; a hump behind the tip may have been developed by not holding the bevelled edge flat. If the blade cuts wild, inconsistent chip sizes, skips on cane surfaces, digs or catches, the burr may be too coarse or there may be no burr at all causing the blade to cut rather than scrape the cane. If at this point the blade is still not performing satisfactorily, it may be necessary to check the radius of the guides. If their radii are not true, the blade will not show properly. A small, fine metal file may be applied to the guides to adjust the show of the blade. If the two guides are not level, only the rear guide is permitted to be slightly higher than the front or leading guide. The guide may be made slightly off center by filing a minute amount off the sides of the guide toward which the cane is displaced. This will help introduce the blade to the cane as the carriage begins its descent. Gordon Reynolds has provided some helpful instructions regarding the sharpening of gouger blades:

> I believe that you can sharpen your blades effectively if they are not very dull or damaged (nicked). Start with a fairly coarse sharpening stone well oiled. Lay the blade on the stone, flat side down. With comfortable pressure pressing the blade downward, rub the blade on the stone in a circle or figure-eight motion for about five minutes. Then do the same on a fine stone. Finally, turn the blade over and lightly touch up the bevelled

> side. Use a small, fine triangular stone or something similar. Use it with gentle strokes like a woman buffing her nails. The plane of the stone should almost coincide with the plane of the bevelled part of the blade. Do just enough to remove any burr on the bevelled side, but not enough to change the angle of the bevel or the circular shape of the radius.[10]

The next step is to place the blade into position in the machine's carriage and to set the cutting depth of the blade. This setting is determined by the thickness of the resulting chip after running the carriage over the cane. The recommended chip thickness varies from .08 mm to .12 mm, .10 mm being optimum. Expressed in inches, the equivalent values would be from .003 inch to .005 inch. The actual size chip will vary slightly depending upon the quality (i.e., texture or hardness) of the cane and the individual gouging technique in the form of pressure exerted on the carriage during a stroke.

The fourth step is to center the blade with respect to the guides and to the gouger bed. The center point or peak of the blade, depending on the type of blade, should first be aligned with the center point of the guide. A slight margin of variability is found here and it is left to the taste and sensitivity of the reedmaker to make the adjustment. Some practice and experience is necessary. If the potential exists, as on the Reynolds' machine, the blade can then be centered over the bed. To check this alignment, gouging cane should produce chips from the center of the cane on the bed. One helpful technique is to draw pencil marks from side to side on the cane in the bed. After passing the carriage over the cane once or twice, the pencil marks should be removed along the middle of the cane.

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[10] Gordon Reynolds, personal correspondence.

Also, on the last strokes of the gouger carriage when the roller wheel just contacts the roller bar, reverse the cane. If the blade is fairly well centered, only a slight trace of cane (if any) will be removed on this last stroke. If any does come off, it should be from the direction in which the blade is displaced (generally the rear side of the gouger bed). If the blade is still not centered, it will be necessary to begin the entire setting up of the gouging machine again. The centering of the blade is most important in determining the thickness, contour, and rate of the gradation of thickness of the gouged cane.

The final step in setting up the gouging machine is to adjust the depth of the gouge. This is accomplished by limiting the descent of the carriage as described above. The resulting thickness of the gouge is the final variable in the gouge process. David Ledet notes that measurements of gouged cane ".57 - .59 mm in the center tapering to .40 - .45 mm on the sides is a good, useable average." Mr. Ledet attempts to diminish the importance of specific and precise measurements of cane, citing variability of such aspects as measuring devices, touch, and cane quality variations. "Because of the nature of the cane, it is impossible and undesirable to control certain of the variables except within tolerances."[11]

There are, however, some legitimate factors which might determine certain tendencies in gouge thickness settings on a gouging machine. Some of those factors include: texture of the cane, climate, the soaking of the cane, technique, scraping quality, and tonal and pitch considerations.

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[11]Sprenkle and Ledet, The Art of Oboe Playing, p. 51.

The texture of the cane seems to affect the resulting gouge tendencies. First, hard-textured cane seems to gouge thicker than does soft, grainy cane. Second, the texture of the cane may lead the reedmaker to prefer a certain thickness. Ledet notes that "hard cane generally requires a thinner gouge."[12] However, John Patterson and Earnest Harrison have demonstrated that it may be preferable for hard cane to be gouged thicker.[13] Since the cane texture generally becomes harder and vascular bundles become more dense with increasing proximity to the bark, hard cane should be left thicker so that when scraped, the vibrating portions of the reed are the more suitable soft-textured, innermost fibers. Likewise, softer cane would benefit from a thinner gouge since the cane utilized would be that which is closest to the bark.

Climate is another factor influencing gouge. Because of the nature of cane, moisture tends to cause the cane to swell, while dryness makes it shrink. In warm, humid climates such as in the southern states of Florida and Louisiana where the relative humidity is almost always over seventy per cent, the cane almost never has an opportunity to totally dry out. It is constantly in a slightly swollen state. For this reason, it is generally preferable to have cane gouged slightly thinner than if the same cane were to be used in a dryer climate. Temperature also influences the reaction of the cane. Lower temperatures tend to produce lower pitch levels, while higher temperatures produce higher pitch levels. Preliminary results show that cane of

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[12] _Ibid_., p. 52.

[13] John Patterson and Earnest Harrison, personal interviews, Baton Rouge, Louisiana, 1974.

greater thickness produces higher pitch levels with a corresponding relationship between thinner cane and lower pitch.

The length of soaking time in preparation for gouging is also a critical factor. Cane soaked for a long period will swell. Gouged in this condition and measured, then dried and measured again, cane will shrink as it dries, altering the dimensions of the reed, sometimes quite drastically. It is wise to consider this factor when measuring cane. The amount of soaking time required can vary; it is generally recommended to allow four to six hours soaking time but to take care not to allow the cane to become waterlogged. "Cane can become permanently spoiled if it becomes waterlogged."[14] Some oboists prefer to gouge cane completely dry. Generally, this technique can produce a much smoother, finer gouge surface which is highly desirable, but dry cane does tend to dull a gouger blade very quickly. Interestingly, the writer observes that the Reynolds machine functions much more successfully with well-soaked cane, while the Michel machine seems to operate more satisfactorily with cane dry or nearly dry.

Finally, the gouge thickness can be said to influence the playing and scraping qualities. Ledet summarizes this concept:

> Variance of thickness of the center and balanced gradation on either side of it will dictate the length and contours of the lay of the reed. In turn, the lay of the reed largely dictates the reed's playing response. As a general rule, the thicker the gouge, the more wood must be removed from the cane by scraping; the thinner the gouge, the less wood can be removed from the cane by scraping.[15]

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[14] Goossens and Roxburgh, Oboe, p. 39.

[15] Sprenkle and Ledet, The Art of Oboe Playing, p. 48.

Gordon Reynolds explains the significance of the proper setting up of the gouging machine in his instructions: "Gouger adjustment is a little like reedmaking, in that some practice is required before one gets an intuitive feel for the changes to be made; there is some art to it."[16]

Shaping the Cane

The shaping of a reed is the process by which the piece of gouged cane is trimmed to form the taper of the reed. An oboe reed when finished is generally wider at the top or tip, narrowing to the point where the cane is bound to the metal staple. The width at the top, width at the binding, and the point and rate at which the cane tapers are the critical factors in the shape of the reed.

The shaper is the tool which serves as a template (see Figure 9). It consists of the shaper tip (the mold over which the cane is placed for cutting), the handle where the tip is mounted, and a clamping device which can be made tighter and looser to firmly hold the cane in position on the tip. Other tools required are an easel and a sharp razor or knife.

To begin the procedure of shaping cane, the gouged cane should be soaked in water a length of time sufficient to allow water to fully penetrate the cane. An indication that the cane is fully soaked is that the cane sinks in the water. The soaked cane is placed on an easel, identifying the center of the length of the cane, and a knife is lightly rolled across the bark marking the middle of the cane. The cane is then placed on a knife edge with the mark across the bark

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[16] Reynolds, Instruction Manual, p. 3.

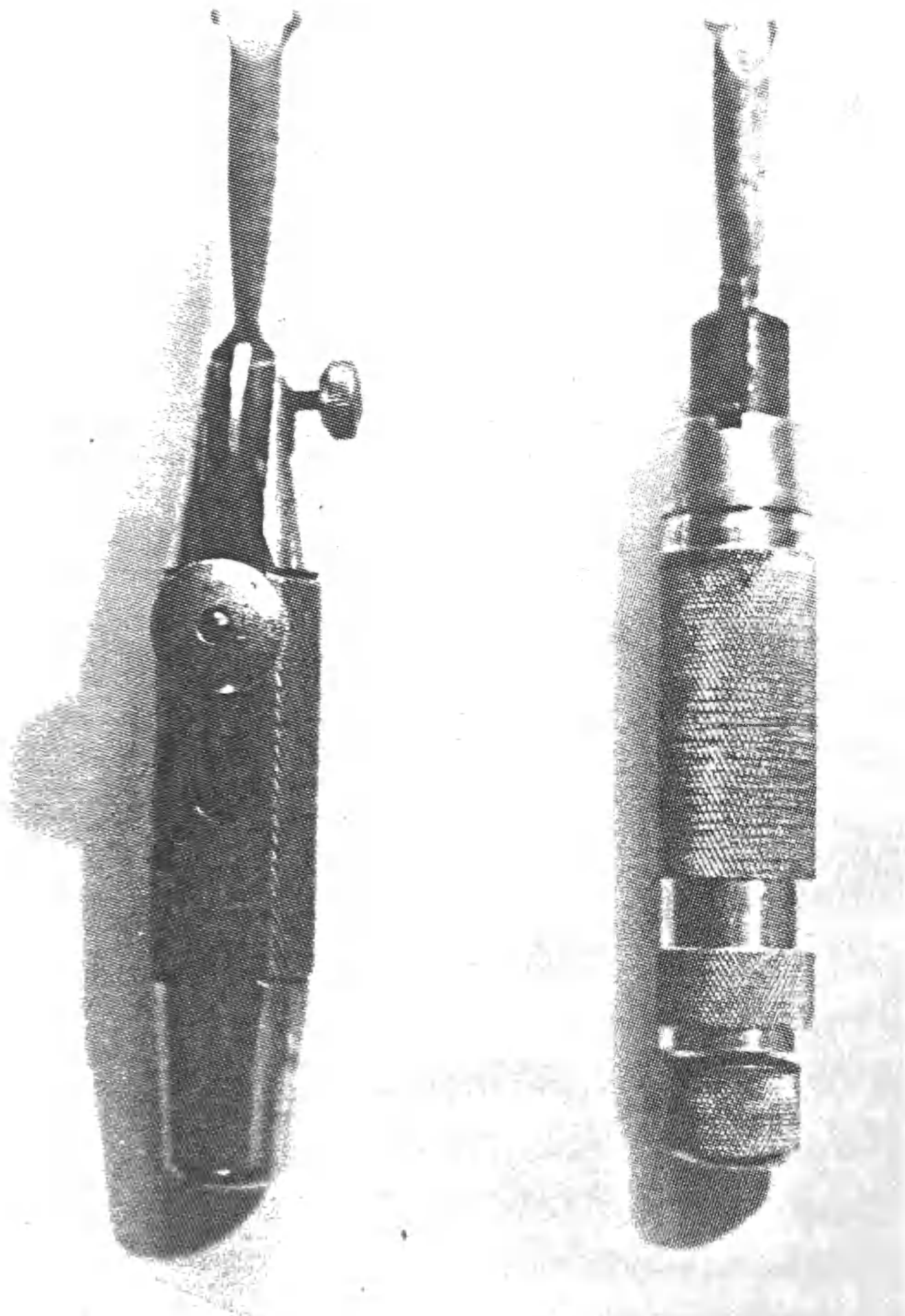

Figure 9. Shapers by Angelo (left) and Bhosys (right).

directly over the edge of the knife, and the two ends are brought together, folding the cane. If the scoring of the reed was cut too deeply, the cane will separate too much or break when folded. Over-soaking the cane causes the cane to become brittle and folding may again result in cracking or breakage.

The folded cane is placed on the shaper tip. Frequently, the folded cane will be too wide to fit between the "ears" at the top of the shaper; the sides of the cane must then be trimmed slightly near the fold. The cane is placed onto the shaper tip and aligned so that the fibers of the cane run parallel to the length of the tip and the center (spine) of the cane is directly over the center (axis) of the shaper. The cane is secured by the clamps. Care should be taken not to allow the clamps to be placed too high on the tip or to be clamped too tightly. Excessive tightening crushes the fibers of cane under the clamp, causing a restriction in their vibration potential. It is helpful to avoid placing the clamps above the point that the cane is bound to the staple (the top of the string binding).

The razor or knife, well sharpened, is then drawn down each shaper edge from the ears to the base of the shaper tip. Great care must be taken to insure that the cane conforms exactly to the sides of the shaper. Any aberration in the contour of the cane's shaper edge will be likely to result in leakage of air. Generally the knife should be held at a ninety degree angle to the flat blade or sides of the shaper tip.[17] Angling the knife edge further will remove more cane, resulting in a narrower overall shape of the cane. If the reed-maker prefers to sideslip the blades of the finished reed, it is

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[17]Goossens and Roxburgh, Oboe, p. 39.

possible to encourage that slippage by severely angling the razor on only one blade on each side. This causes the one narrower blade on each side to tuck into the larger blade producing the desired displacement of the blades.

The amount of soaking time also affects the resulting shaper size. Since the cane fibers have a tendency to swell when soaked and to shrink when dried, the dimensions of the reed's shape can be controlled to some degree by the amount of soaking. Shaping oversoaked cane produces cane with a slightly smaller size than that of the shaper tip due to the effect of the cane's shrinkage during the drying process.

An illustration of the variety of sizes and styles of shaper tips is found in Table 2. The measurements were taken from points 5 mm below the top of the shaper (in the area of the tip of the finished reed), 15 mm below the top (the heart area of the reed), 20 mm below the top (the taper of the reed), and 30 mm below the top (the throat area of the reed). Since different sizes and shapes of shaper tips are so numerous, some considerations in the choice of a shaper would include the instrument, the reedmaking style, the gouge, the embouchure and physical qualities, the playing style and the personal taste of the oboist.

TABLE 2

SHAPER TIPS

Tip Description	1*	2	3	4
Angelo 'A'	.273**	.265	.247	.181
Prestini C1	.274	.256	.239	.173
Prestini C2	.286	.265	.247	.182
Tabuteau	.288	.275	.256	.193
Bhosys	.315	.290	.271	.204

*Measurements from top of shaper tip:

1 = down 5 mm, tip
2 = down 15 mm, heart
3 = down 20 mm, taper
4 = down 30 mm, throat

**Expressed in inches.

CHAPTER III

EXPERIMENTATION AND ANALYSIS

This chapter deals specifically with the influence of gouge and shape on the pitch and tone quality of the oboe. The purpose of this study was to determine whether any relationships exist between the parameters of gouge and shape and the playing qualities of the finished reeds. In order to accomplish this, it was necessary to prepare reeds with cane of varying dimensions and then to describe and analyze the resultant qualities of the reeds. The preparation of the cane critical to this study involved the application of specific concepts and techniques of gouging and shaping as described in Chapter II. The reeds were made and their playing qualities were measured and evaluated. Through the analysis and subsequent interpretation of the resultant data, a determination can be made regarding the relationship between cane dimension and tonal quality.

Procedure

The initial step in the process of the study involved the preparation of the experimental cane samples with the variable parameters being the gouge and shape. The experimental settings required the use of cane with two contrasting gouge contours (one strong or thick and the other thin or weak) along with two contrasting shaper dimensions (one fairly narrow and the other extremely wide). The preparation of

the experimental cane required the preliminary adjustment of the gouging apparatus. The two machines described were regulated so as to produce the two required gouge contours. The Michel machine was used for the strong gouge contour and the Reynolds for the weaker. The gouged cane was then shaped using shaper tips, one by P. Angelo, which is considered moderately narrow (designated 'A' by Angelo), and one by Bhosys, which is extremely wide (see Figure 10).

The resulting four groups of gouged and shaped cane were measured with critical dimensions being those at the center, ribs, and edges of the cane. The cane from each of these groups was then bound to the staples and scraped to its finished state. To account for the numerous variables present (such as the organically inconsistent quality of cane and the human inconsistency in the scraping process), a minimum of twelve reeds was made for each of the four experimental cane settings.

At the completion of the scraping process, the reeds were ready for analysis. The first step was to subject each reed to a spectrum analysis. The spectrum analyzer breaks down a complex tone into its component parts and plots each of the components (partials) on a graph. The spectrum analyzer projects the graph onto a screen, but an X/Y recorder was attached to simultaneously record the spectrum graphs on graph paper to provide a visual record of the analyses. (All spectrum analysis graphs are collected in Appendix A.) The analysis of pitch was accomplished with the aid of a Conn strobotuner. The spectrum analyzer was calibrated to display frequency levels, but these were difficult to read accurately.

Data forms were prepared in which the intensities of each of the partials present in a tone were assigned numerical values for

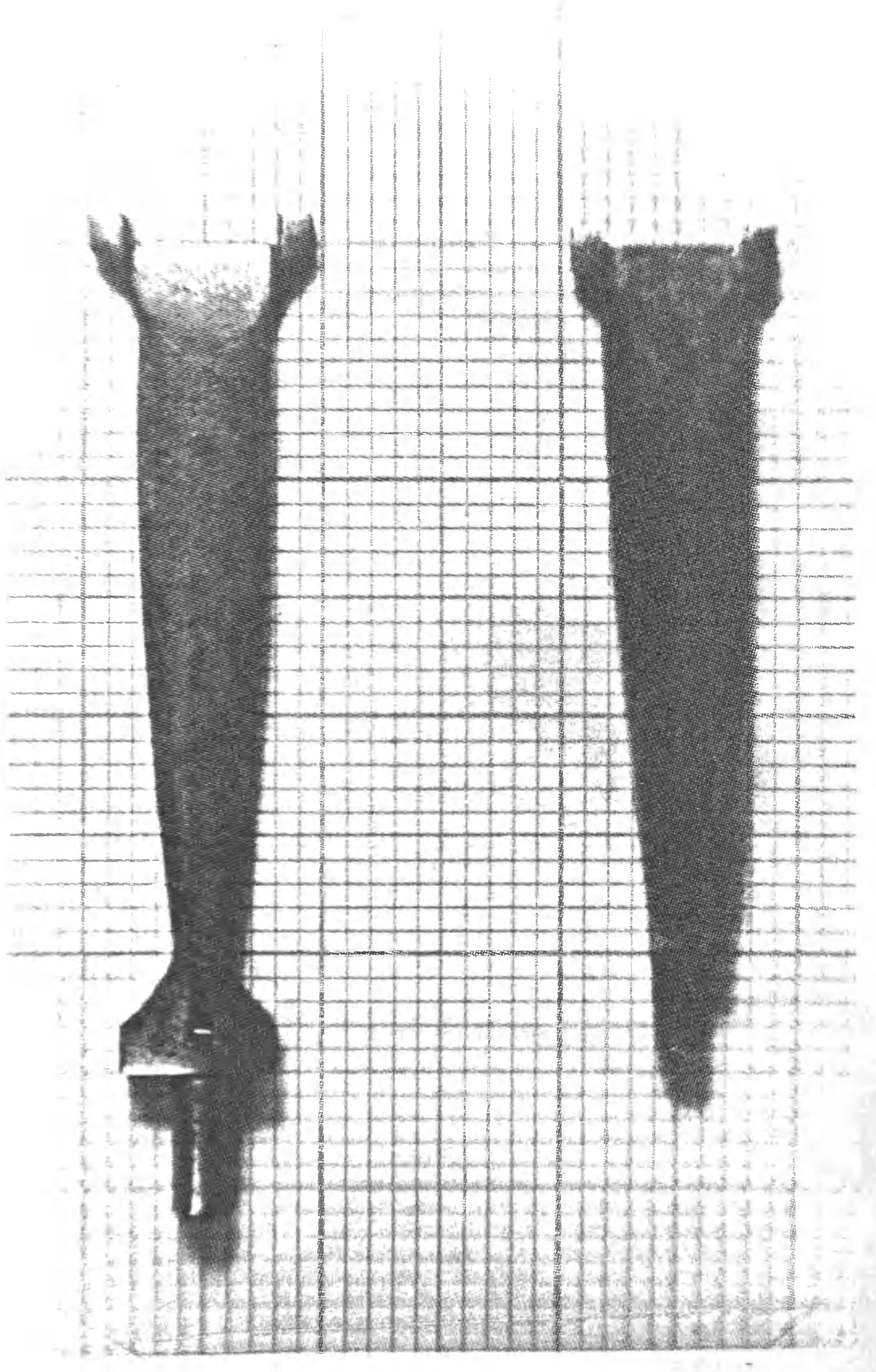

Figure 10. Shaper Tips by Angelo (left) and Bhosys (right).

analysis. These forms were subsequently encoded, including 5,472 data points, onto University of Florida Computing Center Data Coding Sheets. Included on these sheets are: identification (group, subject and pitch numbers), spectrum analysis data (intensity of partials in numerical values), and the computer program which included job code, the type of analysis program, and the input group which described to the computer how to find and sort the data. The Statistical Analysis System[1] was executed by the computer utilizing the ANOVA analysis package. All of this coded information was key-punched onto computer cards and fed into the computer. The computer read, interpreted, and subsequently printed out the analysis of the data (see Appendix B).

Selected Reed Analysis

The Selected Reed Analysis represents a sampling of reeds from each of the four experimental reed groups. It is a survey of the reactions and tendencies of the reeds of each group to the experimental settings of gouge and shape. The selection included reeds demonstrating some of the better, poorer, and most typical playing qualities of each group. A subsequent collection of observations correlates the interaction of the parameters of gouge and shape with the subjective evaluations of the playing qualities of the reeds. Observations of the playing quality of all experimental reeds are included on the following Experimental Data Forms which are sorted by group and subject number (Tables 3-50). The criteria for evaluation included information regarding aperture, resistance, response, pitch, tonal quality, and the crow of the reeds. Recorded on the Experimental Data Forms

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[1]Statistical Analysis System Institute Inc., SAS Circle, Box 8000, Cary, North Carolina 27511.

are the values of the intensity for all recorded partials of each of the six selected pitches as well as the dimensions of the gouged and shaped cane before binding and the total length of the reed when evaluated.

Group I

Reed 1: This reed is an example of one of the most successful reeds of this group. This reed exhibits a substantial depth of tone seen by the great intensity focused in the lower partials of each tone. The envelope of this reed would contain two peaks or formants: the first, nearest the fundamental, is very marked; the second is a smaller peak which is also concentrated toward the lower partials. The extreme strength of the first formant provides the reed with excellent pitch stability.

Reed 3: The spectrum envelope of reed number 3 contains two relatively strong peaks which cause a great deal of conflict. This is the worst reed of this group. The first formant is relatively weak and thin while the second formant contains significant partial content. In performance, the reed appears to be struggling to locate a single significant mode of vibration. The dimensions of the shaped cane are among the strongest of the group. In addition to being slightly asymmetrical in shape, the aperture closes flat (the center closes simultaneously with or before the sides). The extreme strength of the gouge (note the degree of taper from center to sides) causes the improper closure and the resultant severe emphasis on the higher partials and significant upper formant. The pitch level of the reed is consistently high and is significantly above the average of the group.

Reed 25: This reed is included to illustrate an unfinished reed. It has many very good basic qualities and represents the most typical characteristics of this reed group. It has a good foundation of tone in the pronounced first peak near the fundamental. It exhibits good response, aperture, resistance, and overall tone quality. It does, however, require above average control in terms of pitch but maintains a consistent and well-balanced timbre throughout the range of the oboe. The crow has a slightly dominant upper partial attributable to excessive length of the tip. This balance contributes to the slightly higher intensity levels of the highest partials. Finishing this reed would require a simple rebalancing of the reed by trimming the admittedly long tip, refining the tip after clipping to restore the original response and resistance, followed by pronouncing the "windows" in the back of the reed to emphasize further the lower partials. The effect would be to minimize the upper partials and to reinforce the lowest partials and enlarge the first formant of the tonal envelope.

Group II

Reed 4: This reed has a generally dark and stuffy quality. The reed has a prominent buzz or edge to the sound, particularly above f^1, due to the poor closure of the reed which has a markedly asymmetrical aperture. The depth of the tone is illustrated by the strength of the lower partials of each pitch except b^{b1} which is quite buzzy or raspy. Note here the extreme drop after the fundamental and the pressure level which is distributed with relative strength up into the fifth partial. The edge or brightness throughout the reed is seen in the moderately high intensity of all partials of each pitch, distributed quite evenly across the spectrum. This high intensity may also be

influenced by the large aperture size which results in the great blowing resistance and, in turn, high sound pressure level.

Reed 5: This reed is an example of an inferior quality reed where virtually every aspect is deficient. The tone quality is very bright and unfocused. The pitch is very difficult to control. Even the pattern of the lowest series of patials in each tone is unpredictable in shape. This coupled with the sharp peaks in the upper partials produces wildly eccentric playing qualities. The severe instability is caused by the presence of more than one area of strong overtone content. The consequence is a competition for a dominant vibrating pattern. The spectrum analysis for the pitches c^1, f^1, and b^{b1} provides an excellent illustration of this conflict.

Reed 41: This reed demonstrates some of the best overall playing qualities of this group of reeds. The shape of the partials' intensity curve in this reed is one of the most predictable of the group. In general, the curve has a pronounced peak in the lowest partials of each pitch. The remaining partials exhibit a gradual roll-off in the higher partials. It is interesting that dimensions of the shaped cane are among the smallest or weakest of Group II. Note particularly the difference between the center and shaper edge dimensions. Although the pitch level of this reed is good and among the best of the group, the reed's tendency is to be slightly below pitch. This may be directly attributed to the relative weakness of the cane's gouge contour compared to others in this group. Also, the lower pitch seems to encourage the lower partials, providing for more apparent depth of tone.

Group III

Reed 19: This reed is distinguished by its most unusual tonal spectrum; the quality is fair to good, but definitely edgy or raspy. The aperture is asymmetrical contributing to the raspiness. The first formant is clearly defined but the partials within it are highly erratic. The d and c^1 are particularly notable since the intensities of the fundamental partials are stronger than the intensities of the second and third partials. Likewise, the intensities of the fundamentals of the bb^1 and eb^2 are weaker than those of the second and third partials. This eccentric structure was not frequently encountered in this study. The closure of the aperture due to the asymmetrical gouge contour seems to contribute to the unusual response of the reed and also to the presence of strong activity in the second peak area resulting in the moderately bright quality and the chirpy or edgy quality noted in its playing response.

Reed 21: This subject represents one of the poorest reeds of this group. Although the gouge contour is symmetrical, the dimensions of the shaped cane are among the strongest of the group. The excessive strength of the ribs and edge of the reed make the aperture more reluctant to close as it should from each side toward the middle. Again, the partials comprising the first formant are extremely eccentric. The d has a highly uncharacteristic marked depression in the second and third partial. The g has no peak resulting in the reed's indecision regarding its fundamental mode of vibration. The c^1 has a moderate peak for the first formant but the second peak is represented by an unpredictable jump in the sixth partial. The f^1 is normally marked by two extremely dominant partials in modes one and two and relatively

insignificant activity above, but in this case it receives strong competition from partial four. The b^{b1} and e^{b2} normally exhibit a strong fundamental with a more or less predictable roll-off but here the activity is significant even in the highest partials. The consequence is a reed with a bright, buzzy, unfocused, uncontrollable, and penetrating tone. The eccentricity of the overtone spectrum is made obvious by its unpredictable playing quality and lack of homogeneity throughout the registers of the oboe.

Reed 31: By way of contrast, subject 31 is one of the more successful and typical reeds of this group. The reed was analyzed while still quite new and after some use has appeared to become more homogeneous. The gouge contour is a good example of the weaker gouge structure with its taper to the sides which are quite weak. Consequently, upon initial scraping, the aperture of the reed was nearly closed. The reed was then scraped in an attempt to open the aperture by using a kind of leverage. Scraping the spine out of the back of the reed, making a relatively large "window," caused the tip areas of the blades to tend to flay apart. As is typical, this scraping would generally make a reed brighter in quality and flatter in pitch. This perhaps explains any slight emphasis in the upper partials of each series. The length of the reed (substantially shorter than normal) resulted from the compensation for the flatness in pitch and the attempt to minimize the upper overtone predominance by shortening the tip.

Reed 32: Reed number 32 is an excellent reed. It features a very consistent and predictable peak centered near the fundamental of each pitch. A considerable proportion of the total intensity is packed into this pronounced formant. As in other reeds which exhibit this

tendency, the pronounced formant can be predicted when the octave crow is well-balanced and integrated. A slight predominance of the upper octave of the crow is noted, particularly in the pitches g and c^1, and in the slight weakness of pitch in the upper register. A slight trimming of the tip would probably rectify these minor problems. The characteristics of the gouge contour are also significant to the playing quality. The cane measurements are again notably weak at the shaper edge. This gouge contour is definitely weaker than in the strong gouge of Groups I and II, but the strength from center to rib is substantial enough to provide the necessary strength or heart to the reed. The weakness of the sides appears to contribute to the concentration of lower overtones also found in reed number 31.

Group IV

Reed 11: This subject was one of the least successful reeds of Group IV. The performance quality of this reed is totally unacceptable. It features a bright, edgy timbre with a distinct lack of pitch center. The control of the reed in the areas of pitch and tone quality is very poor primarily because of the lack of resistance due in part to the poor scrape but also to the poor closure of the aperture. The resulting tonal spectrum has a relatively strong second formant in the upper partials. The strength of this second peak is uncharacteristically strong for this group of reeds. Of particular interest is the prominent second peak on the pitch c^1. The sixth overtone measures the greatest intensity of the series, setting up a strong competition for the principle mode of vibration at a great distance from the fundamental. The first formant is also unpredictable, having uncharacteristic

weaker second and third modes of vibration on the pitch d, while on the pitch g, the third mode of oscillation has a severe and unexpected dip.

Reed 12: The texture of the cane used in reed 12 is somewhat soft and grainy. Consequently, the gouger blade did not make a clean cut which then left the gouge surface rough and irregular. Although the aperture is of normal size and is relatively symmetrical in shape, the closure of the reed is again affected. It appears that the irregular opening of a reed such as this reduces the fundamental mode of vibration by not allowing the aperture of the reed to close smoothly and consistently from the sides into the middle, in turn causing the instrument to act as though it is not a closed pipe as it is theoretically considered. The intensity levels of the first two partials in d and g are unusually low. The brightness or edge to the sound is reflected in the noticeable peak of the second formant particularly in the low to middle registers. There is a consequent distribution of the overall intensity level into the higher partials.

Reed 24: This reed is one of the better and more typical reeds made from this combination of gouge and shape. The gouge contour is symmetrical and has a sharp gradation from the rib to the shaper edge resulting in cane with sides quite thin. The mid-section of the reed balances the side by a strong relationship between the center and rib. The tone, predictably, has a dark rich sound throughout most of its playing range. The characteristic two formants are present but the higher one is concentrated more closely to the fundamental, further emphasizing the depth of the tone. The width of the reed and the extreme thinness of the sides of the reed promote the moderate flatness

of the pitch level. The intonation of the reed is fairly consistent within itself but is lower throughout the reed, accounting for the slight instability and difficulty of control. Basically, this is a good reed and is representative in many ways of its group.

General Observations

The relationships which exist between the cane dimensions and the pitch and tonal qualities can be observed by their interaction with the playing qualities of the reed. The aperture of a reed, for instance, was often critical in determining the reed's playing quality. Several factors influence the aperture. The foremost consideration is the closure of the reed, which ideally occurs inward from each side, closing last at exactly the centerpoint. This closure is influenced in turn by the symmetricality of the gouge contour from the center to each side and also by the strength of the gouge or the rate of taper of the cane from center to sides. The study of the reed samples as seen in the Experimental Data Forms indicates that the stronger gouge contours tend to produce a brighter tonal quality. In the case of the stronger gouge, the extreme strength along the ribs and edges with respect to the center creates an aperture which tends to close in a flat manner. With the sides reluctant to close, the center collapses first,

> . . . the reed tends to snap shut at the end of its swing rather than closing smoothly. . . . This means that a relatively low blowing pressure will take one into the loud playing part of the playing range, in which the reed remains closed over an appreciable fraction of each cycle. This results in considerable production of high harmonics even at the pianissimo level.[2]

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[2]Benade, Fundamentals of Musical Acoustics, p. 447.

TABLE 3

EXPERIMENTAL DATA FORM

Procedure Data $nX_{1}0$ Subject Number 1 Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	40**	33	36	77	63	30	6	4	14	24	5	10	20	7	8	2		
g	35	25	120	76	6	3	12	8	7	4	2	1						
c	44	48	45	21	5	25	42	5	4									
f	54	82	5	6	1	3	1											
b^b	90	42	22	26	17	1												
e^b	84	72	53	35														

*Reed Data: 23.75/22/18.5 Length: 70.5 mm

Resistance: very good; provides stability throughout all registers

Aperture: symmetrical, average opening size

Pitch: very good stability; well-focused center

Crow: good, solid octave, hint of third lower octave; excellent response

Tone: substantial depth with brilliance; quite good

Excellent reed; well distributed curve with extreme strength in lower partials.

*All gouge dimensions are expressed in thousandths of an inch in the following order: center/rib/shaper edge. **These values were arbitrarily chosen and indicate only relative intensities.

TABLE 4

EXPERIMENTAL DATA FORM

Procedure Data $nX_{1}0$ Subject Number 2 Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	55	27	50	42	63	35	9	5	14	23	10	17	5	3	5	1		
g	49	21	29	10	20	15	29	14	11	10	6							
c	10	62	37	12	36	53	5	4	2	1								
f	65	65	8	15	6													
b^b	64	56	12	38	19													
e^b	80	10	4	13														

Reed Data: 23/22/19.5 Length: 70 mm

Aperture: slightly large, asymmetrical; closure off center; blades close flat

Crow: octaves, upper partial predominant, low octave sluggish. Can be forced to rattle

Resistance: good to fair

Pitch: flat in upper register with lack of control; otherwise good

Tone: above average; depth with edge or brightness

TABLE 5

EXPERIMENTAL DATA FORM

Procedure Data nX_10 | Subject Number 3 | Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	60	39	42	47	26	3	16	20	22	20	4	17	0	2	5	4		
g	33	61	67	63	11	18	38	56	25	17	12	16	2					
c	35	77	11	13	25	52	62	3	11									
f	58	98	7	9	12	18	8											
b^b	65	60	29	44	9													
e^b	85	46	25	40														

Reed Data: 24.25/23/19 Length: 70.25 mm

Aperture: Moderately large; asymmetrical.
Blades close flat

Crow: undefinable, response uncontrollable

Resistance: very little

Pitch: very poor; no stability

Tone: quality very poor; bright, edgy, unfocused and inconsistent

Relatively low strength of partials 1 - 5, dip, substantial large peak; unpredictable curve.

TABLE 6

EXPERIMENTAL DATA FORM

Procedure Data nX_2O Subject Number 13 Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	18	27	36	8	42	13	1	0	6	5	1	2	2	1	0	1	1	
g	10	11	48	10	1	10	1	4	4	2	0	1	1					
c	19	45	17	5	4	15	1	1	2	3								
f	9	73	2	9	4	1												
b^b	45	16	8	5	8	1												
e^b	24	6	5	4														

Reed Data: 23/22/17.5 Length 71 mm

Aperture: average, symmetrical

Crow: solid octave, well-balanced, excellent response

Resistance: excellent, though some leakage at shaper edge

Pitch: excellent; good stability

Tone: excellent; good depth and slightly darker than others in group

Well distributed curve; very predictable. Intensity level overall quite low.

TABLE 7

EXPERIMENTAL DATA FORM

Procedure Data nX_20 Subject Number 14 Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	40	47	60	24	29	12	8	7	3	4	8	1	5	2	8	1	2	
g	5	8	58	18	1	19	10	22	13	2	2	1	1					
c	13	62	24	20	13	13	13	7										
f	48	80	4	5	9	2												
b^b	61	55	5	12	20													
e^b	83	53	10	2														

Reed Data: 23.5/22/18 Length: 69.75 mm

Aperture: symmetrical, moderately large
Crow: unstable, octave crow present, undefinable rattle; good response

Resistance: good
Pitch: good stability; good control
Tone: full, rich and bright

Note the strength all across the spectrum. Brightness attributable to shortness of reed length and strength of gouge.

TABLE 8

EXPERIMENTAL DATA FORM

Procedure Data nX_2O Subject Number 15 Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	40	38	58	30	61	12	7	2	18	25	8	2	7	3	2	1		
g	6	31	57	1	10	12	20	37	5	8	0	1	1					
c	23	62	28	10	8	7	22	1	5	3								
f	44	68	6	13	10	1	1											
b^b	58	44	10	10	3													
e^b	50	57	6	9														

Reed Data: 24/22/16 Length: 70.5 mm

Aperture: asymmetrical, moderate size.

Crow: well-balanced, solid octave; response-lower crow resistant

Resistance: good, stable

Pitch: very good; control and stability good

Tone: excellent, with brilliance

Excellent reed. Predictable curve. Good strength in lower partials, balancing strong second formant.

TABLE 9

EXPERIMENTAL DATA FORM

Procedure Data nX_3O Subject Number 25 Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	50	62	46	47	51	19	7	7	10	29	5	2	6	2	3	1		
g	45	15	70	30	12	8	12	8	11	2	2	8						
c	49	53	6	17	6	34	38	5	11									
f	53	87	3	4	19	1												
b^b	66	48	4	29	15	3												
e^b	80	44	5	12	1													

Reed Data: 24/22.5/18 Length: 70.75 mm

Aperture: symmetrical, moderately large

Crow: good octave crow; upper crow dominant; good response

Resistance: good

Pitch: eccentric; average stability requires control

Tone: generally good but inconsistent, needs extra control and adjustments.

Excessive tip length reflected here.

TABLE 10

EXPERIMENTAL DATA FORM

Procedure Data nX_30 Subject Number 26 Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	44	48	47	58	59	18	3	13	0	10	11	10	6	5	4	3	7	
g	30	15	43	10	3	24	20	15	5	3	2	7	3					
c	21	56	37	18	6	43	5	12	2									
f	5	65	6	13	11	9	1											
b^b	58	50	2	19	14	3												
e^b	47	29	20	15	1													

Reed Data: 24/23/18 Length: 70 mm

Aperture: asymmetrical, tendency toward center closure

Crow: upper partials predominant, rattle undefinable; responds too easily

Resistance: very little

Pitch: poor stability

Tone: bright, lacking focus, unacceptable

Aperture closure due to strength of gouge (center to rib) affects tone. Significant strength in upper partials. Unpredictable.

TABLE 11

EXPERIMENTAL DATA FORM

Procedure Data nX_3O Subject Number 27 Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	52	48	52	45	50	44	11	2	11	8	15	12	15	1	2	1		
g	35	22	68	50	6	8	10	18	2	5	1							
c	10	32	50	12	3	27	13	2										
f	30	68	0	16	14	1	1											
b^b	72	32	30	15	2	1												
e^b	73	72	6	15	1													

Reed Data: 24.75/23-22/18-16
Length: 70.25 mm

Aperture: nearly normal despite asymmetrical gouge

Crow: responsive with upper octave predominant. rattle can be forced, response good.

Resistance: good

Pitch: stability not good, much control necessary

Tone: good but not consistent. Requires much embouchure control

Upper partials reflect rattle crow. Unstable strong second formant.

TABLE 12

EXPERIMENTAL DATA FORM

Procedure Data nX_4O Subject Number 37 Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	30	26	56	52	46	29	5	1	14	3	12	7	8	3	4			
g	25	33	49	40	3	8	13	25	12	16	2	1						
c	38	42	53	24	14	33	24	5	1									
f	50	76	9	2	10	7												
b^b	58	42	9	44	8	1												
e^b	57	45	3	13														

Reed Data: 24/23/19 Length: 71 mm

Aperture: good

Crow: lower octave sluggish

Resistance: quite a bit, strong gouge

Pitch: good stability with sharp tendency

Tone: bright; fairly good first formant.

Predictable lower partials with low pressure levels - distributed out to upper partials.

TABLE 13

EXPERIMENTAL DATA FORM

Procedure Data nX_4O | Subject Number 38 | Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	32	30	45	70	55	20	4	8	19	20	15	3	10	4	3	2	3	
g	35	14	76	48	14	9	11	3	2	0	0	2						
c	30	42	63	32	15	36	8	4	2									
f	25	61	7	8	2	4												
b^b	70	26	24	18	18	1												
e^b	68	59	5	28														

Reed Data: 23/22/18 Length: 70.5 mm

Aperture: symmetrical, very good

Crow: upper octave predominant; good response, average stability

Resistance: good

Pitch: good

Tone: slightly bright and consistent

Mildly unpredictable curve; substantial strength in upper partials.

TABLE 14

EXPERIMENTAL DATA FORM

Procedure Data nX_4O Subject Number 39 Group I

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	27	18	41	69	17	11	9	6	7	11	18	5	5	2	3			
g	23	10	64	45	14	5	22	26	19	5	1	1						
c	12	49	55	21	15	37	11	3	1									
f	49	45	0	8	9	2												
b^b	70	45	4	24	13													
e^b	77	60	8	17														

Reed Data: 25/22.75-23.75/16-18
Length: 71 mm

Aperture: nearly symmetrical, large
Crow: unruly with extraneous tones

Resistance: insufficient
Pitch: quite eccentric, lack of stability
Tone: bright and unfocused; dip in partials 2 and 3.

Wildly unpredictable curve; unbalanced in partials 1-4. Edgy in upper register.

TABLE 15

EXPERIMENTAL DATA FORM

Procedure Data wX_10 Subject Number 4 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	39	22	50	104	115	32	16	3	8	14	19	4	4	10	14	3	2	1
g	41	88	62	60	23	20	22	25	28	18	14	5	3					
c	48	55	80	11	11	23	3	11	6	1								
f	54	82	13	2	4	2												
b^b	90	31	32	25	20	5												
e^b	90	73	23	6	1													

Reed Data: 24.5/22/17 Length: 70 mm

Aperture: Moderately large, symmetrical

Crow: Octave with predominant low crow, poor sluggish response in low register; can be forced to rattle.

Resistance: quite strong

Pitch: fair due to great resistance; upper register unstable, especially f.

Tone: overall dark, rather tubby; prominent buzz, g^1 and above.

TABLE 16

EXPERIMENTAL DATA FORM

Procedure Data wX_10 Subject Number 5 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	67	25	60	52	47	40	7	6	18	12	8	16	12	3	7	2		
g	46	58	37	49	17	23	6	19	20	17	6	2	3					
c	25	63	33	22	2	60	54	33	6									
f	62	80	3	13	33	15	1											
b^b	67	73	22	53	44	10												
e^b	90	56	29	21														

Reed Data: 24.5/22.5/17 Length: 69.5 mm

Aperture: large, asymmetrical; poor closure; blades close flat.

Crow: unstable, octaves undefinable, rattles; fair response.

Resistance: not sufficient

Pitch: good level, but lacking stability; no focus, especially mid and upper registers.

Tone: poor, bright, honky. Difficult to control and unpredictable especially as pitch rises.

TABLE 17

EXPERIMENTAL DATA FORM

Procedure Data $wX_{1}0$ Subject Number 6 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	62	17	38	60	73	13	14	2	5	8	12	2	3	6	4	1	1	
g	53	18	38	39	27	10	26	20	11	10	10	2						
c	17	59	50	14	14	10	26	32	4									
f	50	71	1	24	10	6	2											
b^b	41	53	10	5	8	3												
e^b	79	47	38	20														

Reed Data: 25/23.5/29 Length: 69.5 mm

Aperture: large, severely asymmetrical

Crow: octave with noticeable "chirp," rattles when forced. Poor response with air leakage at shaper edge

Resistance: strong to air and embouchure

Pitch: near normal level due to extreme resistance; control is lacking and requires much effort.

Tone: fair

TABLE 18

EXPERIMENTAL DATA FORM

Procedure Data wX_2O Subject Number 16   Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	40	45	62	28	52	28	1	0	2	15	15	14	4	7	7	4	1	
g	20	17	75	56	13	17	20	35	18	10	4	3	2					
c	36	47	60	2	16	29	45	12	7									
f	30	81	8	4	10	2	1											
b^b	63	64	22	10	28	3	1											
e^b	63	20	5	1														

Reed Data: 24/23-22/18   Length: 69 mm

Aperture: moderately large, symmetrical; blades tend to close flat

Crow: Octave with predominant upper crow; lower octave sluggish. Forced rattle, adds lower partials; response fair

Resistance: quite strong

Pitch: good level; control difficult in mid to upper registers

Tone: deep with prominent brightness; not homogeneous

TABLE 19

EXPERIMENTAL DATA FORM

Procedure Data wX_2O Subject Number 17 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	37	50	63	67	61	24	1	3	12	30	2	7	5	2	1	1	1	
g	20	17	65	40	8	25	38	5	7	5	0	2						
c	39	52	45	10	10	60	16	5										
f	60	84	7	6	19	2												
b^b	66	56	17	20	32	2												
e^b	83	62	2	17														

Reed Data: 24.5/23.5/16 Length: 68.25 mm

Aperture: large, slightly asymmetrical

Crow: Good octave with predominant upper partial; low partials when forced; moderate response but difficult to articulate

Resistance: very; great intensity required

Pitch: fair; upper register flat, unstable

Tone: dark, weaker gouge

TABLE 20

EXPERIMENTAL DATA FORM

Procedure Data wX_2O Subject Number 18 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	30	50	55	26	58	5	11	18	13	7	10	7	13	10	11	4	3	
g	17	22	60	30	17	12	18	48	20	30	10	1						
c	46	47	46	9	30	56	41	28	10									
f	58	80	1	6	5	8												
b^b	55	56	23	20	17	10												
e^b	50	63	15	4														

Reed Data: 25/21-24/19-18 Length: 36.5 mm

Aperture: highly asymmetrical; extremely large opening

Crow: indefinable, very poor response

Resistance: extreme, particularly to embouchure.

Pitch: poor, complete lack of control

Tone: unacceptable; bright, unfocused

TABLE 21

EXPERIMENTAL DATA FORM

Procedure Data wX_3O Subject Number 28 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	33	49	52	40	52	10	4	20	24	7	17	8	10	4	2	2	1	
g	27	48	19	35	12	35	25	10	9	3	0	3						
c	18	40	27	9	12	1	12	4	2									
f	26	82	3	26	20	3	2											
b^b	50	69	4	25	16													
e^b	90	31	7	15	2													

Reed Data: 24.5/22-23/18 Length: 67.5 mm

Aperture: extremely large, asymmetrical (poorly gouged surface)

Crow: indefinable with poor response

Resistance: extremely strong

Pitch: very poor, no center; very flat particularly upper register

Tone: unacceptable (weakness of formant)

TABLE 22

EXPERIMENTAL DATA FORM

Procedure Data wX_3O Subject Number 29 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	39	36	14	38	75	5	0	7	13	27	14	5	12	3	2	1		
g	20	49	57	37	16	20	35	20	5	1								
c	16	37	4	5	16	33	18	9	2									
f	33	87	1	3	20	4	1											
b^b	45	59	5	13	18	3												
e^b	95	60	10	15														

Reed Data: 24.5/22.75/17.25 Length: 68.75 mm

Aperture: large, good closure

Crow: solid octave, well balanced with fair response

Resistance: moderate

Pitch: close to average, fair stability; flatness marked in upper register

Tone: fair, darker, more consistent than 28 and 30 (weaker gouge, good scrape)

TABLE 23

EXPERIMENTAL DATA FORM

Procedure Data wX$_3$0 Subject Number 30 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	45	43	34	30	64	9	1	1	36	13	8	2	5	1	1	1	2	
g	30	53	18	11	19	2	10	10	7	3	2	3						
c	25	10	15	20	6	15	8	7	5									
f	40	36	0	18	4	0	1											
b^b	50	53	16	14	10	1												
e^b	77	40	6	22	2													

Reed Data: 24/22-22.5/14-15 Length: 69 mm

Aperture: slightly asymmetrical, moderate opening

Crow: octave well balanced, not well integrated; lower octave can be forced; good response

Resistance: good (weakness of edge)

Pitch: quite good (unusual in this group)

Tone: hollow, tubby quality with penetrating edge; fair

TABLE 24

EXPERIMENTAL DATA FORM

Procedure Data wX_40 Subject Number 40 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	37	19	12	18	12	20	13	11	20	10	5	5	11	5	2	5	1	
g	30	27	55	55	8	21	12	18	8	1	2	7						
c	31	52	63	21	10	24	5	4	8									
f	40	63	5	14	10													
b^b	59	8	20	5	11													
e^b	75	58	9	6	2													

Reed Data: 24/22.25-22.75/16-18
Length: 69.25 mm

Aperture: moderately large, symmetrical
Crow: octave, lower partials in rattle, response resistant to articulations in low register

Resistance: moderate
Pitch: fair, weakness in upper register
Tone: rather uncharacteristic curve and unpredictable tone

TABLE 25

EXPERIMENTAL DATA FORM

Procedure Data $wX_4 0$ Subject Number 41 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	23	55	58	59	77	22	0	3	7	7	9	8	12	2	5	2	1	
g	19	48	2	70	21	10	20	15	14	4	0	0	4					
c	35	55	64	10	14	29	39	12										
f	57	80	2	2	23	3												
b^b	77	26	8	7	10													
e^b	84	55	10	7														

Reed Data: 23.75/22/14-16 Length: 69.5 mm

Aperture: moderately large, symmetrical

Crow: octave crow; forcing adds few partials; good response

Resistance: moderate

Pitch: fair to good

Tone: dark and full with pronounced darkness

TABLE 26

EXPERIMENTAL DATA FORM

Procedure Data wX_40 Subject Number 42 Group II

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	31	50	46	58	62	8	4	6	13	8	8	18	11	2	0	0	1	
g	48	51	67	33	17	22	7	23	16	3	1	2						
c	32	61	39	6	18	45	36	1	7									
f	59	79	1	5	16	10												
b^b	70	12	1	40	10													
e^b	40	72	30	24														

Reed Data: 24/22-23/17.5-18
Length: 69 mm

Aperture: moderately large, slightly assym-metrical, tendency to flat closure

Crow: octave, additional indefinable rattles; ease of response

Resistance: good

Pitch: good

Tone: fair; no center or clear focus (unpredictable curve and asymmetrical aperture); bright mid-upper registers, strong second peak

TABLE 27

EXPERIMENTAL DATA FORM

Procedure Data nY_10 Subject Number 7 Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	57	39	26	106	63	24	6	8	5	8	23	7	12	9	6	4	0	
g	77	27	77	95	13	30	24	20	41	17	9	3						
c	57	58	9	12	21	105	12	11	4	1								
f	38	85	6	21	3	4												
b^b	80	60	29	37	8													
e^b	90	78	48	35	1													

Reed Data: 24.25/21.25/16 Length: 69.5 mm

Aperture: normal, symmetrical

Crow: dominant upper octave; good response to articulation (slightly irregular gouge surface)

Resistance: good

Pitch: stable, fairly consistent, easily controlled

Tone: good, distinct edge; core to sound (strong formant)

TABLE 28

EXPERIMENTAL DATA FORM

Procedure Data nY_10 Subject Number 8 Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	52	13	32	36	56	35	10	1	16	28	16	4	8	2	5	2	2	
g	49	39	14	65	20	8	18	46	10	8	0	8						
c	22	60	37	9	18	65	32	4	4									
f	60	87	7	38	6	2	1											
b^b	62	19	19	38	4	3												
e^b	90	60	37	28														

Reed Data: 24/21-22/13/16 Length: 70.5 mm

Aperture: asymmetrical (irregular gouge contour); reed collapses

Crow: well-balanced; predominant lower octave; good response

Resistance: good
Pitch: good stability
Tone: good quality

TABLE 29

EXPERIMENTAL DATA FORM

Procedure Data nY$_1$0   Subject Number 9   Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	48	53	51	19	62	23	9	5	15	16	8	9	15	6	3	1		
g	40	53	67	18	5	11	20	46	28	13	1	2	1					
c	47	60	26	20	13	25	21	12	3									
f	68	59	12	20	11	5	1											
b^b	60	2	5	145	10	1												
e^b	65	58	23	20														

Reed Data: 23/21-22/15-15.27
Length: 70.25 mm

Aperture: larger than average; incorrect closure, slight aberration in tip center; convergence of gouge radius

Crow: octave response good; upper octave predominant; rattle in crow shows lack of integration

Resistance: good
Pitch: good stability; sharp
Tone: distinct edge; bright

TABLE 30

EXPERIMENTAL DATA FORM

Procedure Data nY_20 Subject Number 19 Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	44	17	18	56	69	24	2	7	25	8	22	4	5	3	3	5		
g	15	40	68	30	10	8	50	31	18	5	1	6						
c	45	29	40	8	7	12	11	1	1									
f	60	72	10	37	6	1												
b^b	26	48	35	12	7													
e^b	14	42	46	12														

Reed Data: 23.75/21/16 Length: 70.5 mm

Aperture: average, asymmetrical closure off center

Crow: octave crow responsive, upper c predominant; can be forced to rattle; response easy in low and high registers; eccentric

Resistance: good

Pitch: very good stability; octaves have good focus, center

Tone: good to fair, "chirp" or edge; controlled with embouchure; aperture closure

TABLE 31

EXPERIMENTAL DATA FORM

Procedure Data nY_2O Subject Number 20 Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	40	41	41	12	38	25	2	1	5	5	21	4	6	4	4	0	0	
g	15	23	5	20	2	6	7	15	11	10	4	0						
c	45	58	30	18	17	24	15	4										
f	30	65	8	16	22	8												
b^b	32	62	16	34	23	1												
e^b	95	30	4	3	1													

Reed Data: 23/21/14-15 Length: 70 mm

Aperture: good

Crow: not good; "chirp" in crow; perhaps problem with scraping tip; upper partial predominant, sluggish response

Resistance: good

Pitch: very good; some minor eccentricity

Tone: very good; full, rich tone; rich in high vibrations; good projection

TABLE 32

EXPERIMENTAL DATA FORM

Procedure Data nY_2O Subject Number 21 Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	45	11	12	53	61	20	2	19	24	16	8	2	2	0	1	2		
g	15	23	39	28	13	22	35	38	18	5	0	5						
c	30	54	33	7	17	40	3	2	8									
f	40	73	4	30	16	5	1											
b^b	62	8	25	28	14													
e^b	60	52	22	38	1													

Reed Data: 23.75/22/16 Length: 70 mm

Aperture: moderately large; flat type of closure; strong gouge contour

Crow: octaves, not well balanced; can be forced into rattle; response of lower octave sluggish

Resistance: fair to good

Pitch: fair; requires considerable control

Tone: poor; buzzy, raspy, unfocused, penetrating; not homogeneous through registers

TABLE 33

EXPERIMENTAL DATA FORM

Procedure Data nY_30 Subject Number 31 Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	37	48	40	9	79	12	2	2	5	15	13	7	8	4	2	0	1	
g	35	54	35	44	9	11	6	10	8	2	0	5						
c	20	33	26	9	10	36	7	2	1									
f	62	90	8	13	20	6												
b^b	50	40	2	20	12													
e^b	86	24	5	5														

Reed Data: 23.5/21.5-22/13-14
Length: 69 mm

Aperture: originally quite small; scraped to adapt

Crow: solid octave crow; integrated, excellent response

Excellent overall.

Resistance: very good

Pitch: good; requires more embouchure control than normal

Tone: mellow; strong first formant

TABLE 34

EXPERIMENTAL DATA FORM

Procedure Data nY_3O Subject Number 32   Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	39	32	33	55	60	13	0	3	8	7	3	3	5	1	1	1	1	
g	27	44	30	40	4	7	7	24	17	12	2	1						
c	55	23	46	6	10	31	34	1										
f	22	73	4	9	12													
b^b	62	55	6	7	9	1												
e^b	62	45	11	19														

Reed Data: 23.25/20.5-21/12   Length: 70 mm

Aperture: normal

Crow: solid octave; slight dominance of upper c; integrated; excellent response

Resistance: excellent

Pitch: slight weakness in upper register, easily controlled

Tone: very good; used in performance; strong first formant

TABLE 35

EXPERIMENTAL DATA FORM

Procedure Data nY_3O Subject Number 33 Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	40	36	37	16	75	6	2	2	11	15	6	8	10	6	2	1	2	
g	34	55	45	40	15	1	20	2	14	2	1	1						
c	26	28	42	9	7	39	13	3										
f	47	83	3	2	8	5	1											
b^b	62	40	2	7	26													
e^b	75	47	13	10														

Reed Data: 23.35/21/16 Length: 70.5 mm

Aperture: moderately large, symmetrical; poor gouge surface

Crow: upper octave predominant; third lower octave present

Resistance: above normal; inconsistent

Pitch: good

Tone: fair to good, eccentric; edgy with brightness at attacks

TABLE 36

EXPERIMENTAL DATA FORM

Procedure Data nY$_4$0 Subject Number 43 Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	43	37	22	50	58	37	11	1	7	12	9	14	19	5	1	2		
g	24	40	74	60	19	7	15	12	36	7	7	3						
c	42	53	55	22	15	43	24	12	1									
f	54	78	1	11	18	3												
b^b	75	48	10	3	13													
e^b	64	25	44	13														

Reed Data: 23.75/22/18 Length: 70 mm

Aperture: normal

Crow: solid octave, not well integrated; upper octave predominates; response fair, sluggish to articulation

Resistance: very strong, tiring (leakage between blades)

Pitch: quite good

Tone: good, full; requires great intensity

Strength of partials and consistent distribution of strong partials across the series reflect high levels of intensity required.

TABLE 37

EXPERIMENTAL DATA FORM

Procedure Data nY$_{4}$0 Subject Number 44 Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	40	24	25	60	64	26	0	0	9	14	8	5	8	2	3	0		
g	50	40	66	40	7	10	45	40	38	10	0	4	2					
c	18	59	34	16	32	56	25	5	2	6								
f	65	77	2	20	7	4												
b^b	65	52	8	27	28													
e^b	80	30	20	20														

Reed Data: 23/21.75/12-15 Length: 70.25 mm

Aperture: good; originally very small

Crow: solid octave; upper c dominant with hint of rattle from upper partials; good response

Resistance: very good

Pitch: very good

Tone: very good quality; overall very good reed; used in performance; high intensity levels in first formant; two clear peaks in envelope

TABLE 38

EXPERIMENTAL DATA FORM

Procedure Data nY_40 Subject Number 45 Group III

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	44	26	51	28	45	16	14	0	12	23	3	7	13	5	1	1	1	
g	17	5	40	19	5	15	28	20	20	8	1	1	1					
c	13	56	50	9	16	43	10	3	4									
f	56	84	2	4	6	7	1											
b^b	80	66	19	10	7	1												
e^b	70	30	5	13														

Reed Data: 23/21.25/16-18 Length: 70 mm

Crack developed on gouge surface; changing quality; ranged from fair to poor.

TABLE 39

EXPERIMENTAL DATA FORM

Procedure Data $wY_1 0$ Subject Number 10 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	69	53	25	118	46	19	6	2	15	20	11	5	2	4	2			
g	68	82	19	100	7	17	8	35	26	22	8	4	3					
c	52	59	56	14	17	41	18	9	2	6								
f	44	53	4	34	16	4	2											
b^b	55	60	14	23	9	1	0	1										
e^b	98	74	51	23	2													

Reed Data: 24.25/21-22/14-16
Length: 69.5 mm

Aperture: symmetrical, normal size
Crow: octaves plus indefinable rattles, very responsive

Resistance: very weak
Pitch: flat overall, severe lack of stability; no tonal center
Tone: dark and stuffy; difficult to control

TABLE 40

EXPERIMENTAL DATA FORM

Procedure Data $wY_{1}0$ Subject Number 11 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	50	44	27	56	47	36	13	1	9	15	11	9	5	4	1	1		
g	54	65	9	68	11	10	37	13	12	3	1	4						
c	15	45	59	7	6	60	30	3										
f	60	85	4	7	11	3												
b^b	45	30	7	19	17	1												
e^b	96	60	36	13														

Reed Data: 23/20.5-22/15 Length: 69.5 mm

Aperture: very asymmetrical; closure at extreme sides

Crow: totally indefinable rattle; response too easy

Resistance: very little

Pitch: extremely flat; complete lack of pitch center or focus

Tone: bright edgy quality; poor

Weakness of second and third modes of oscillation in d and g, while c has two peaks of similar intensity in competition; extreme instability.

TABLE 41

EXPERIMENTAL DATA FORM

Procedure Data wY_1O Subject Number 12 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	14	17	35	60	33	41	11	1	4	15	30	5	10	3	0	5	1	
g	13	11	82	10	6	4	6	29	21	2	5	1	1					
c	35	63	50	10	6	25	26	9	4									
f	67	90	3	13	26	5												
b^b	60	52	18	17	15	1												
e^b	76	32	8	3														

Reed Data: 24/21/15 Length: 69.50 mm

Aperture: average; irregular closure due to poor gouge surface

Crow: rattles, no definition of octave; easy response

Resistance: very little

Pitch: very little stability or focus; tendency is flat

Tone: buzzy quality with a deep, hollow tone

Note the shallow first formant, and distribution of intensity to upper range.

TABLE 42

EXPERIMENTAL DATA FORM

Procedure Data wY_2O Subject Number 22 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	40	46	32	38	61	10	1	4	20	12	5	10	8	7	0	2	1	
g	9	8	74	45	15	18	9	17	1	1	0	1						
c	54	46	48	15	22	18	2	3	7									
f	55	80	6	3	11	4												
b^b	81	67	12	11	6	1												
e^b	89	23	18	20	2													

Reed Data: 24/21-22/14 Length: 69 mm

Aperture: moderately large

Crow: octave, hint of lower octave; slightly sluggish; response average

Relatively dark quality but peak of first formant displaced slightly to the right; weaker modes 1 and 2.

Resistance: moderate resistance to air, more resistance to lips, control

Pitch: quite good except for some instability in upper register

Tone: dark, husky quality; good, but tiring to control

TABLE 43

EXPERIMENTAL DATA FORM

Procedure Data wY_2O Subject Number 23 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	44	58	29	50	29	21	7	3	3	18	16	7	13	0	1	1	1	
g	21	40	32	57	11	12	12	26	9	5	1	2						
c	53	57	36	4	20	30	16	3	1									
f	64	80	5	4	4	1												
b^b	65	35	5	6	10	1												
e^b	90	36	7	12														

Reed Data: 23.5/21-22/14 Length: 69 mm

Aperture: extremely large, slightly asymmetrical

Crow: octave, upper more responsive; lower predominant; some rattle

Resistance: very heavy to air and embouchure

Pitch: good in low to mid range; upper register flat; no stability

Tone: good, dark low register; lack of definition and focus to higher pitches

TABLE 44

EXPERIMENTAL DATA FORM

Procedure Data wY_2O Subject Number 24 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	26	54	52	68	60	9	3	3	5	11	14	3	6	3	0	1	2	
g	15	38	56	55	5	20	34	5	5	2	1	13	0					
c	37	60	49	0	24	35	8	2	11									
f	37	89	2	11	7	0	1											
b^b	70	34	21	16	11													
e^b	80	30	30	16														

Reed Data: 23/21/13 Length: 69 mm

Aperture: average

Crow: octave plus lower partials (rattles); well balanced

Resistance: slight to air, moderate to embouchure; requires control

Pitch: unstable, higher registers, especially side octave key notes

Tone: dark, stuffy; playable except for tiring aspect of control

TABLE 45

EXPERIMENTAL DATA FORM

Procedure Data wY_30 Subject Number 34 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	40	25	42	17	48	4	2	6	11	3	4	1	6	2	2	1		
g	39	44	41	39	17	7	7	8	7	1	1	2						
c	9	40	24	9	15	35	6	0	3									
f	45	76	5	14	4													
b^b	62	47	8	21	5													
e^b	92	60	16	3														

Reed Data: 23.75/31/13 Length: 69 mm

Aperture: normal, symmetrical

Crow: octave crow very stable; predominant low octave; good response

Resistance: resistant to air, great stability

Pitch: quite stable due to firm resistance; upper register is sharp

Tone: excellent, dark quality; somewhat stuffy; lack of significant upper partials

Slightly thin gouge with rapid taper results in darker general quality.

TABLE 46

EXPERIMENTAL DATA FORM

Procedure Data wY_3O Subject Number 35 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	40	38	56	12	38	19	4	1	6	7	10	10	7	0	1	2		
g	26	50	65	53	17	7	7	15	12	1	2	1						
c	29	30	57	10	8	41	25	1										
f	45	75	4	24	5	3												
b^b	73	48	6	30	8													
e^b	83	42	3	29														

Reed Data: 23.5/20.5-21.5/14-16
Length: 69 mm

Aperture: moderately large; asymmetrical, closure off center

Crow: octave well-balanced, fairly responsive; extra low partials when forced to rattle

Resistance: very stiff to air minimizing resistance to embouchure

Pitch: good control

Tone: dark, stuffy, hollow

TABLE 47

EXPERIMENTAL DATA FORM

Procedure Data $wY_{3}0$ Subject Number 36 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	42	11	50	64	47	8	3	4	5	8	8	2	5	6	7			
g	17	32	50	49	8	4	6	20	3	4	2							
c	20	25	7	7	11	23	10	3	1									
f	60	93	2	15	8	1												
b^b	80	31	10	44	7													
e^b	98	30	8	5														

Reed Data: 23.5/20.5-21/13-14
Length: 69 mm

Aperture: large, severely asymmetrical, closure off center

Crow: octave crow plus extraneous lower partials, rattle, average response

Resistance: moderate; not sufficient to provide stability

Pitch: extremely erratic, unpredictable; requires considerable adjustment and control

Tone: false dark quality; reed has a raspy quality in open tones and upper register; pronounced second formant, low intensity levels in first formant

TABLE 48

EXPERIMENTAL DATA FORM

Procedure Data $wY_4 0$ Subject Number 46 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	45	14	12	47	50	31	8	2	3	17	4	6	2	1	1	1	1	
g	33	35	77	19	4	9	14	20	9	4	0	2	1					
c	12	62	52	9	13	10	14	7	10									
f	52	95	0	10	9	1												
b^b	77	55	20	15	12	1												
e^b	82	46	7	15														

Reed Data: 23/21/15 Length: 68.75 mm

Aperture: large, symmetrical closure

Crow: octave and rattle; extraneous notes, high and low partials; response too flexible

Resistance: nominal, reed tends to "bonk" attacks

Pitch: unstable and eccentric, considerable effort to control

Tone: unfocused, dark core but too much uncontrolled vibration; edge to tone

TABLE 49

EXPERIMENTAL DATA FORM

Procedure Data wY_40 Subject Number 47 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	35	37	41	21	73	5	1	6	8	18	10	5	3	8	1	0	1	
g	43	58	46	15	10	16	33	21	14	2	1	2						
c	13	61	40	5	3	49	7	3	4									
f	61	87	6	15	4	3	1											
b^b	75	47	6	13	17	1												
e^b	81	12	8	10														

Reed Data: 23.25/20/12 Length: 68 mm

Aperture: extremely large, asymmetrical, closure slightly flat and off center

Crow: octave and extra rattles, primarily lower partials; sluggish, balanced

Resistance: moderately resistant to air, primarily to embouchure

Pitch: quite erratic, octaves quite flat

Tone: dark core, added edge or chirp particularly evident on open fingerings; not well balanced

TABLE 50

EXPERIMENTAL DATA FORM

Procedure Data wY_40 Subject Number 48 Group IV

PARTIALS

PITCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	47	39	47	18	65	8	3	5	23	9	11	9	6	0	4	2	4	
g	45	49	65	24	7	0	20	17	10	2	0	5						
c	10	51	57	8	10	45	38	4	3	2								
f	34	90	1	0	4	1												
b^b	73	48	10	22	13	1												
e^b	90	32	3	1														

Reed Data: 23.25/21/16 Length: 69 mm

Aperture: average, symmetrical; poorly gouged surface

Crow: octave, but uncontrolled rattle; high and low partials

Resistance: little resistance to air or embouchure

Pitch: center and control is very poor; mid and upper registers extremely eccentric, flat

Tone: nominal; very poor; prominent rasp or edge to tone throughout range; lack of any definable center or core of tone

Any aberrations in the gouge surface such as those caused by dull gouger blades or poor quality cane can also cause poor closure with similar tonal consequences. The ideal condition of the aperture is one in which "the reed tip never completely closes the aperture at its end" so that the potential exists for a considerable change in tone color as the vigor of blowing changes.[3] The size of the shaper tip is another critical factor in determining the size of the aperture. The leverage created by the taper of the cane causes the narrower shapes to have smaller openings and the wider shapes to have larger openings.

The aperture size is also an important factor controlling the resistance of a reed since resistance is partially determined by the distance which the two vibrating surfaces must travel during each cycle of their oscillation. Larger openings of the reed generally produce greater playing resistance. "Anything that works against the maintenance of oscillation [requires the musician] to exert more effort in his playing, so as to provide a combination of increased blowing pressure and greater embouchure tension."[4] Resistance is also caused by the apparent stiffness of the reed which is directly attributable to the strength of the gouge thickness of the cane and to the scraping of the reed surfaces. The resistance of the reed is then controlled directly and indirectly by the reciprocal action of the gouge and shape.

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[3]*Ibid.*, p. 446.

[4]*Ibid.*, p. 446.

Intensity is another variable which influences the subjective tone quality of the oboe reeds. The intensity of a tone has a direct effect upon the perceived tonal quality. A change of intensity by an alteration in blowing pressure produces a resulting change in the harmonic content of a tone since when

> . . . starting from pianissimo playing levels there are virtually no harmonics present in the tone beyond the fundamental; then for every doubling of the fundamental component, harmonic 2 increases from its initial tiny value by a factor of $2^2 = 4$; similarly, harmonic 3 will grow by a factor of $2^3 = 8$ for each doubling of the fundamental component.[5]

For this reason it was important to maintain as much as possible the same intensity to provide for effective evaluation. In this study the oscilloscope was utilized to aid in the maintenance and consistency of the intensity.

The shape plays a significant role in the determination of the playing response of the reed. Leon Goossens notes that the shape is "the most idiosyncratic stage of reedmaking."[6] Basic physical laws regulate the relationship between the size or area of a vibrating object and its pitch or tone quality. The aperture is one facet of the reed which is directly influenced by the size of the shape. The width at the top of the reed, the point and rate at which the reed noticeably tapers, and the diameter of the cane determine the aperture of the reed. In general, a wider shape produces a larger aperture and vice versa. The aperture has a direct effect on the playing response and pitch of the reed. Larger aperture reeds require more embouchure

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[5] Ibid, pp. 441-42.

[6] Goossens and Roxburgh, Oboe, p. 38.

pressure and air pressure to control the vibration of the reed since the blades must travel a greater distance. Also, the larger aperture reeds have a correspondingly larger air cavity between the two vibrating blades. The greater volume of vibrating air space results in a lower pitch level. The inverse is also true. As a general rule, the larger the area of the vibrating surface, the lower the resulting pitch, and, consequently, the smaller the area, the higher the pitch. The observations show in addition that wider shapes produce lower pitch and tend to encourage lower partials; narrower shapes tend to increase the upper partials and raise the pitch.

Interpretation

The gouge and shape exert a considerable influence on pitch and tone quality. A comparison of the Pitch Analysis Tables (Tables 51-54) illustrates the influence of gouge and shape on pitch. The size and shape of the shaper tip plays one of the most vital roles in the determination of pitch. As previously stated, the shaper determines the size or area of the vibrating surface of the reed mechanism which is critical to pitch. The shaper also determines the size of the aperture of the reed which directly influences the volume of the reed cavity or air space between the two blades of cane. The importance of this factor is described by Benade: "For a conical woodwind instrument to work properly, the equivalent volume of the reed cavity added to the mechanical volume of its staple . . . must closely match the volume of the missing part of the cone."[7] A

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[7]Benade, Fundamentals of Musical Acoustics, p. 470.

comparison of the Pitch Analysis Tables between the two groups of reeds with varying shape vividly demonstrates the influence of shape on pitch as in the pitch of the reeds of Groups I and II which share the same gouge but vary in shape. Group II demonstrates a pronounced lowering of the pitch level as well as a markedly greater deviation and range of pitch. Reed samples from Group II and to a lesser degree Group IV (which use the wider shape) are among the least consistent reeds of the experimental groups. The averages of the overall deviation in pitch for reeds of Group II and Group IV are -5.01 cents and -1.79 cents, respectively. The reeds made with the narrow shape (Groups I and III) were among the most predictable and consistent. The averages of the overall deviation in pitch for reeds of Group I and Group III are +1.09 cents and -1.01 cents, respectively. This demonstrates the importance of matching the shape with the instrument, player, gouge contour, and scraping techniques due to the strong influence the shape exerts on the oboe reed mechanism. The gouge contour also has a dramatic effect on pitch. A comparison of the Pitch Analysis Tables of Group I and Group III (sharing the same shape dimensions but differing in gouge) demonstrates that the stronger gouge generally produces a higher pitch level. Not only is the level of pitch higher, but a correlation of total length measurements (found on the Experimental Data Forms, Tables 3-50) indicates that the pitch levels are higher even with the increased average length of the Group I reeds. The weaker gouge in the cane produced a slight lowering of pitch and generally lent itself toward a darker type of tone quality. Benade observed this tendency and noted: "In all cases softening or thinning

TABLE 51

PITCH ANALYSIS

Reed Group 1 Procedure Data nX0

				Pitch*		
Reed No.	d	g	c	f	b^b	e^b
1	-7	0	0	0	+1	0
2	-2	0	+1	0	-1	-1
3	0	+1	0	+1	+3	0
13	-3	0	-1	0	0	-1
14	-5	+1	0	+2	0	0
15	-2	+2	+2	0	0	+1
25	-3	0	+1	0	+2	0
26	-5	0	0	0	+3	0
27	-2	0	+4	+1	0	0
37	-5	0	+1	+2	+3	+1
38	-4	0	+2	+1	+2	0
39	-5	-1	+1	+3	0	+1
Mean Score	3.416	.25	.916	.833	1.08	.08

*Deviation in cents. 0 equivalent to a = 440 pitch level.

TABLE 52

PITCH ANALYSIS

Reed Group 2 Procedure Data wXO

	Pitch					
Reed No.	d	g	c	f	b^b	e^b
4	-8	-6	0	0	-18	-10
5	-7	0	0	-15	-25	-17
6	-3	-3	0	0	-15	-15
16	-6	+2	+1	0	0	0
17	-7	-2	0	-2	-6	-4
18	-8	-6	0	-2	-26	-11
28	-5	-2	-6	-14	-23	-12
29	-7	0	-2	0	-12	-10
30	-8	0	0	0	+1	+2
40	-4	-3	0	0	-6	-4
41	-9	-2	+2	0	-8	-4
42	-4	0	0	0	0	+2
Mean Score	-6.33	-1.83	-.41	-2.75	-11.5	-7.25

TABLE 53

PITCH ANALYSIS

Reed Group 3 Procedure Data nYO

	Pitch					
Reed No.	d	g	c	f	b^b	e^b
7	-3	0	+2	0	0	+1
8	-5	0	-2	-2	-3	-1
9	-5	0	0	+2	+4	+4
19	-7	0	0	0	0	+2
20	-4	0	-5	0	-2	0
21	-2	0	0	0	-2	0
31	-6	0	-1	-4	-5	-3
32	-4	0	0	-5	-3	-2
33	-4	0	0	+2	0	0
43	-4	+3	+2	0	0	+3
44	-5	-2	0	0	+3	+2
45	-4	-3	0	0	-1	-4
Mean Score	-4.41	-.16	-.333	-.58	-.75	+.16

TABLE 54

PITCH ANALYSIS

Reed Group 4 Procedure Data wY0

Pitch

Reed No.	d	g	c	f	b^b	e^b
10	-4	-4	-6	-10	-14	-12
11	-5	-2	0	-3	-8	-8
12	-15	-7	-2	0	-15	-18
22	-4	0	+1	-1	-3	-3
23	0	0	+6	+5	-4	-3
24	-4	-1	-1	-3	-3	-7
34	0	0	+2	0	+8	+5
35	-4	+1	0	0	0	0
36	-1	+6	+7	0	+1	-3
46	-3	+1	0	0	+3	+1
47	-2	0	+1	-5	-6	-5
48	-2	0	-5	-3	-5	-4
Mean Score	.36	-.5	+.25	-1.6	-3.83	-4.75

the cane walls of the reed cavity enlarges its equivalent volume."[8] The volume of the reed cavity (as affected by gouge) directly influences the level of pitch as did the shaper size, rejecting the null hypothesis

These principles, applicable to the function of the shape, are an important consideration in the selection of the proper shaper as a critical link in the chain of sound-producing equipment of the oboe.

The formants, regions in the spectrum envelope which exhibit higher peaks of intensity, are important in the description of tone quality (see Spectrum Envelope Graphs, Figures 11-34). The magnitude, placement, and relationship of these formants affect the perception of tone quality. The shape of the general curve and the area under it are significant aspects. Reed quality differs as the levels of intensity under the curve are displaced. The basic oboe quality is one which features two formants in the envelope. The first formant lies in the frequency range near 1000 Hz which happens to coincide closely with the frequency of the c^2 pitch of the reed's crow. "Spectrum components lying near the reed's own natural frequency will be enhanced very similarly."[9]

An observation of the spectrum envelopes shows that the fundamental mode of vibration of pitches in the lower and middle registers of the oboe are not usually as significant as other partials in the first formant. However, the upper register pitches such as bb^1 and eb^2 do not exhibit this characteristic. Benade states that the

> . . . reduction of the tallness of the first-mode resonance peak is a characteristic feature of long, conical woodwind air columns

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[8] _Ibid._, p. 467.

[9] _Ibid._, p. 445.

> in which the missing part of the cone at the apex is relatively short compared to the length of the body of the instrument. Progressively shortening the cone by cutting segments off its large-diameter end lends toward a shortened air column that does not have this property.[10]

In general, reeds which could be described as having a dark overall sound tend to have an envelope with a significant first formant near the fundamental. The most extreme example of this is found in Group IV where the reeds are excessively dark. Here, the second formant is slightly more depressed than in the three other groups. The deviation is relatively small, and the overall intensity of the second formant peak is weak so that the predominant sound is of the first formant which is nearest the fundamental and tends to give the reed a stuffy sound. Brighter reeds tend to have a less prominent peak at the first formant and an associated spreading out of the intensity into the higher overtones increasing the relative strength of the second formant. This tendency can be observed in the reeds of Group I which have the least variability from the mean. Note particularly the spectrum envelope of the pitches g and d. The pitch d has a slightly reduced peak of the first formant, a plateau which results in a slight raising and displacement to the right of the intensity of the second formant. In the note g, the first formant has a marked dip resulting in a reduced area under the surface and a displacement of intensity into the second formant. A slight increase in the intensities in the extreme upper partials leads to a quasi-third formant at the twelfth partial. This group exhibits some of the most consistent reed qualities. Group III reeds (weaker gouge with the same narrow

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[10] _Ibid_., p. 444.

shape as the Group I reeds) exhibit slightly more deviation than those of Group I but less deviation than is found in the reeds of Groups II and IV. The reeds of Group III are darker than those of Group I because of the strength and area of the first formant. The second formant peaks at a lower frequency than in group I which results in another kind of emphasis on the lower partials. Group II reeds' average quality were close to those of the reeds of Group IV; the two groups share the same shape but different gouges. Group II reeds show the greatest deviation from the mean, reflecting the greater inconsistency and lack of stability of the reeds.

Notable features of individual reeds whose playing qualities were considered good were the predictability of the spectrum analysis graph, the intensities of the individual overtones, and the shape of the overall envelope (see the individual Spectrum Analysis Graphs in Appendix A). For example, the tonal spectrum of Reed number 1 on the pitch d (Table 55) exemplifies these particular good qualities and represents one of the more typical reeds of this group. It is marked by very good playing qualities which are exhibited by a general adherence to the mean values of the group of reeds with most values falling well within the limits of standard deviation. In this case, 37 per cent of the 16 measured variables fall outside the standard deviation, yet the overall sound is good because of the shape and predictability of the reed's envelope. The comparison of the spectrum contents of the pitch d of reed number 43 with the mean values and standard deviation measurements illustrates the consistency of this reed (Table 56). Again, the playing qualities of this reed were rated as being good and the subjective evaluation is supported by the

Figure 11. Spectrum Envelope: Group I, Pitch d.

Figure 12. Spectrum Envelope: Group I, Pitch g.

Figure 13. Spectrum Envelope: Group I, Pitch c.

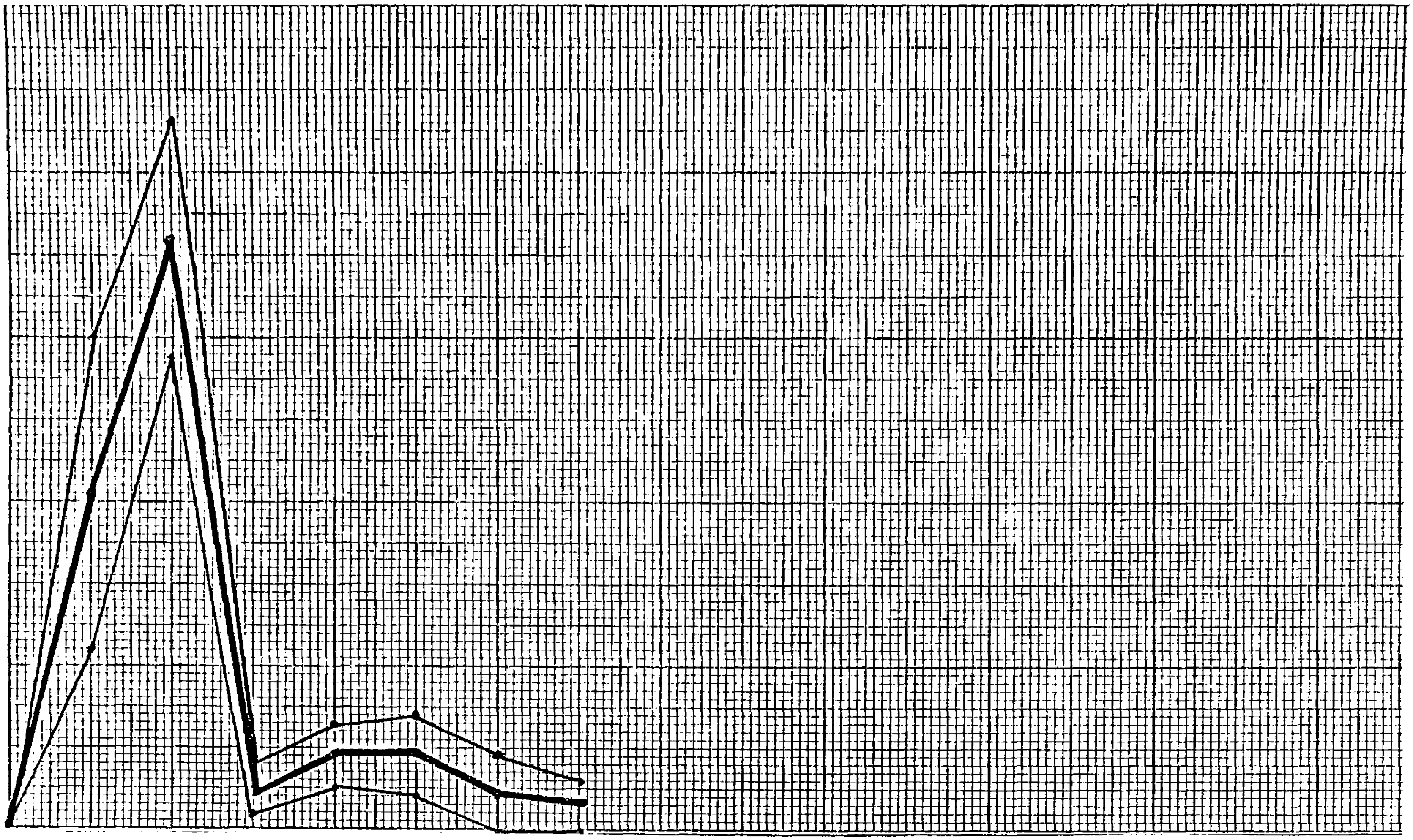

Figure 14. Spectrum Envelope: Group I, Pitch f.

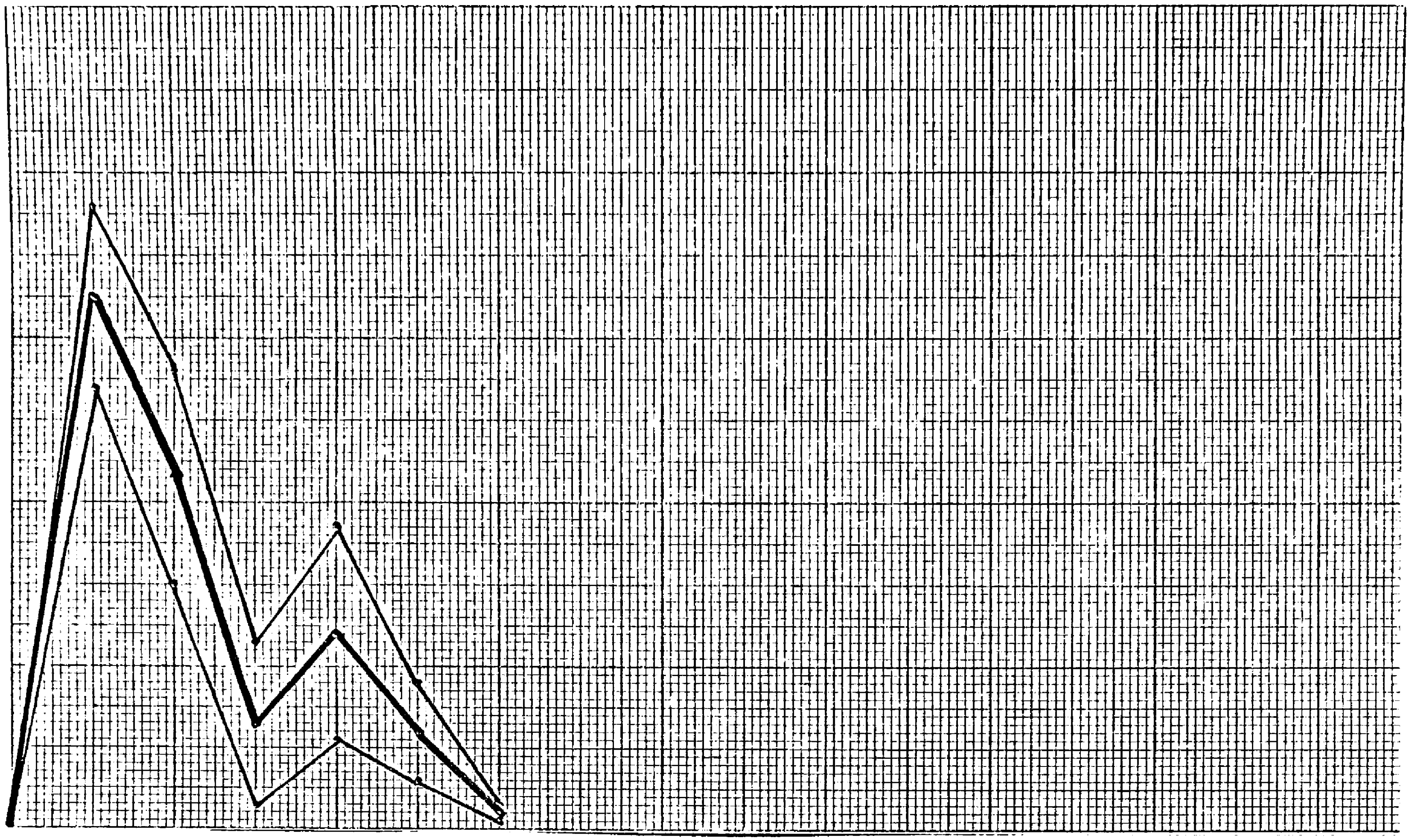

Figure 15. Spectrum Envelope: Group I, pitch b^b.

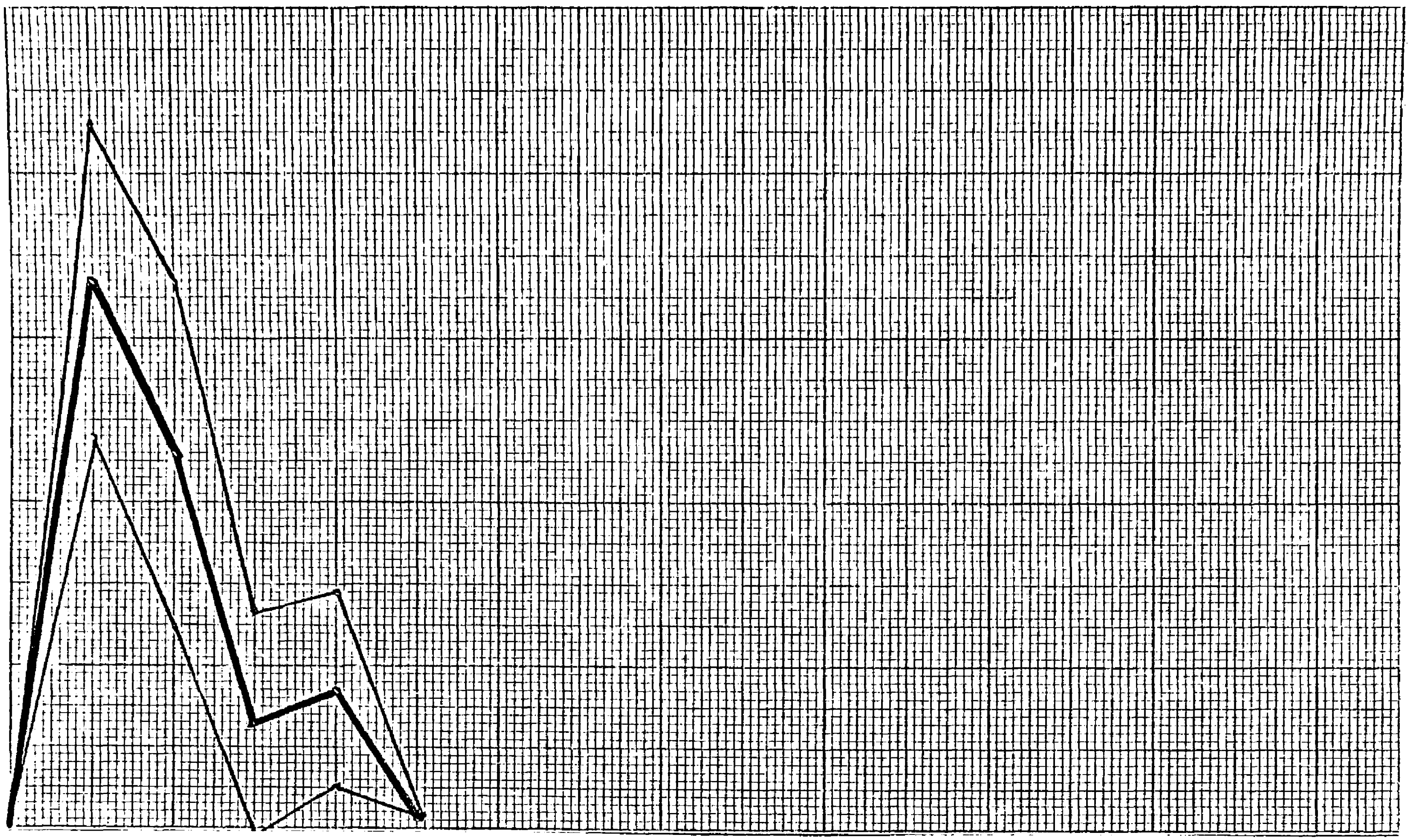

Figure 16. Spectrum Envelope: Group I, Pitch e^b.

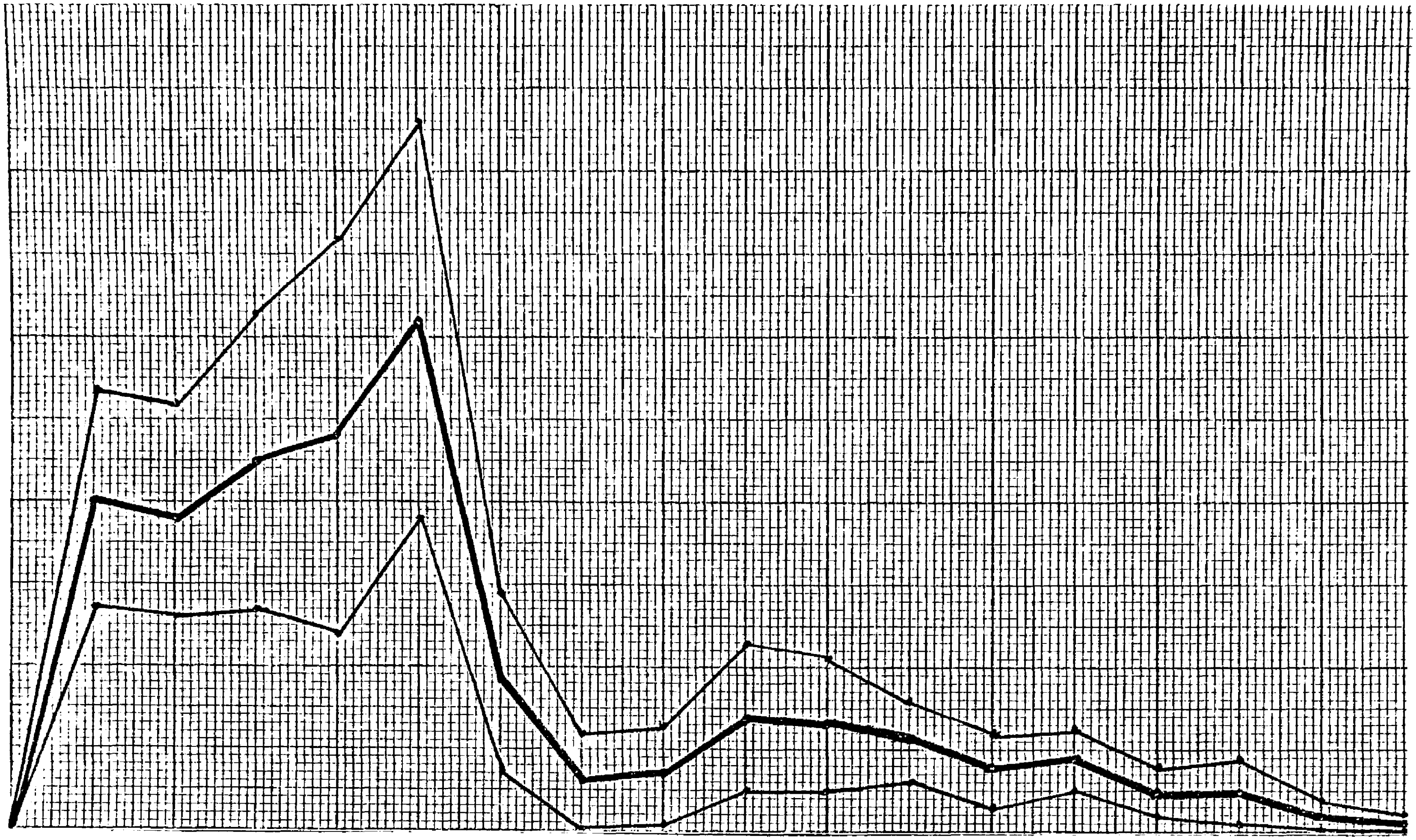

Figure 17. Spectrum Envelope: Group II, Pitch d.

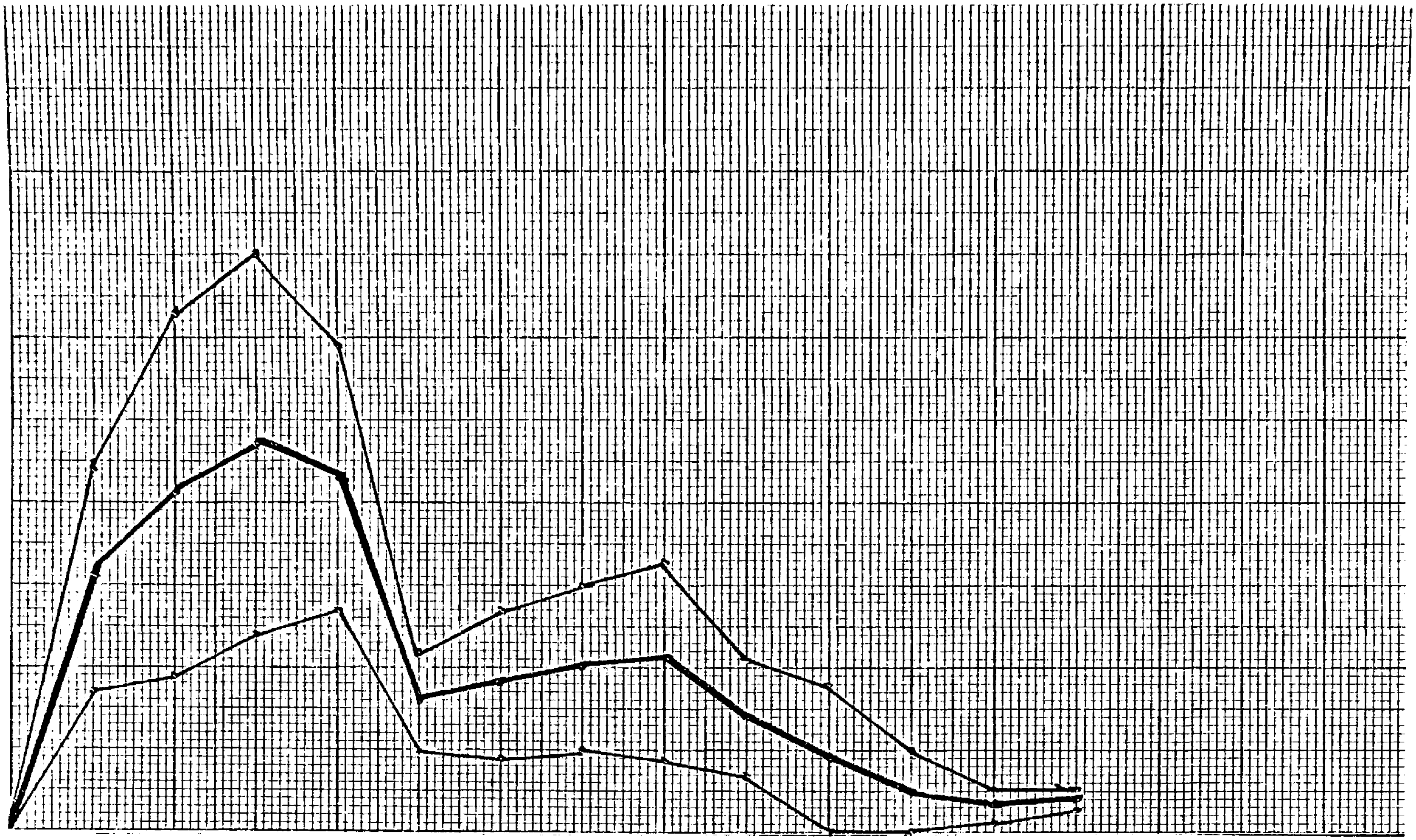

Figure 18. Spectrum Envelope: Group II, Pitch g.

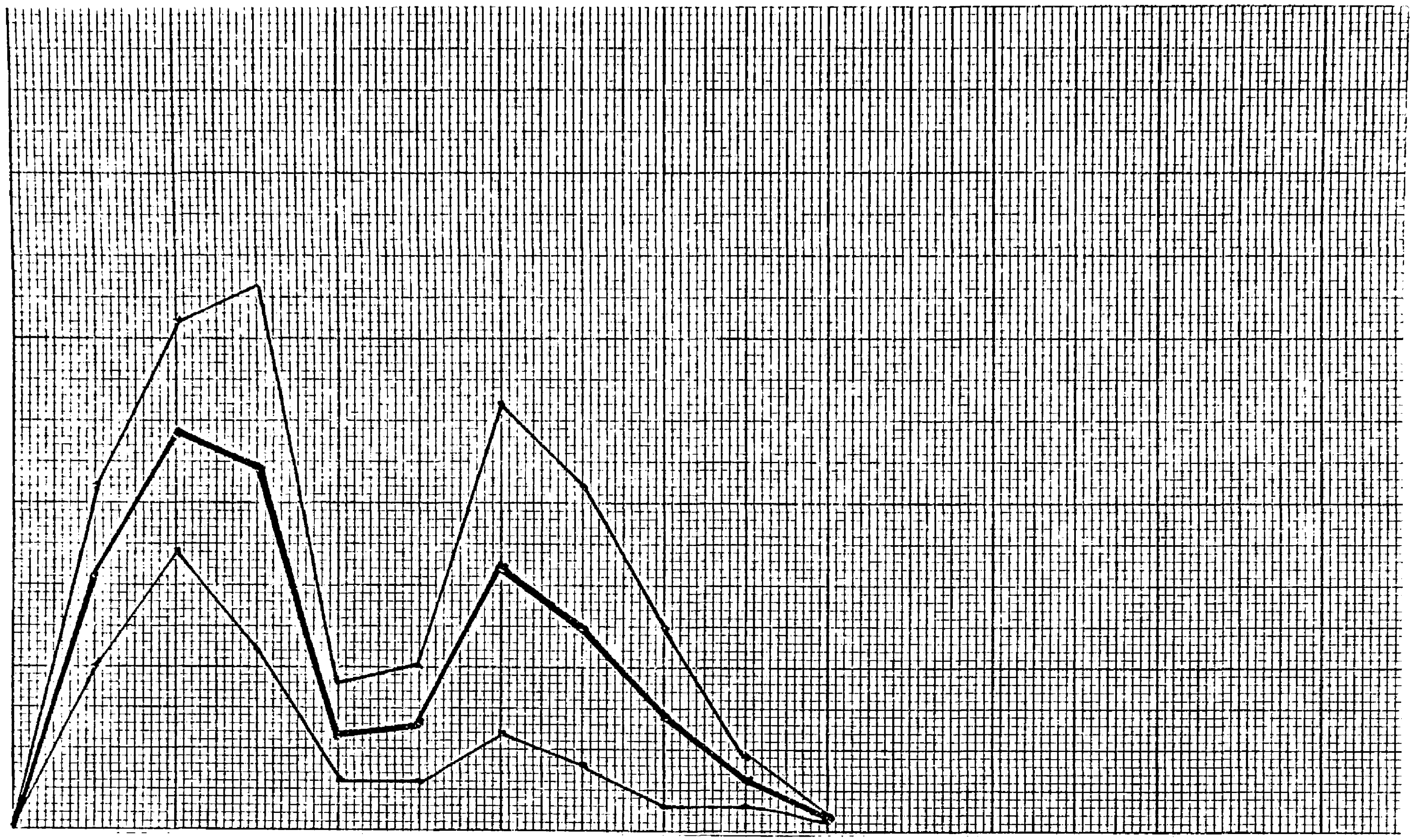

Figure 19. Spectrum Envelope: Group II, Pitch c.

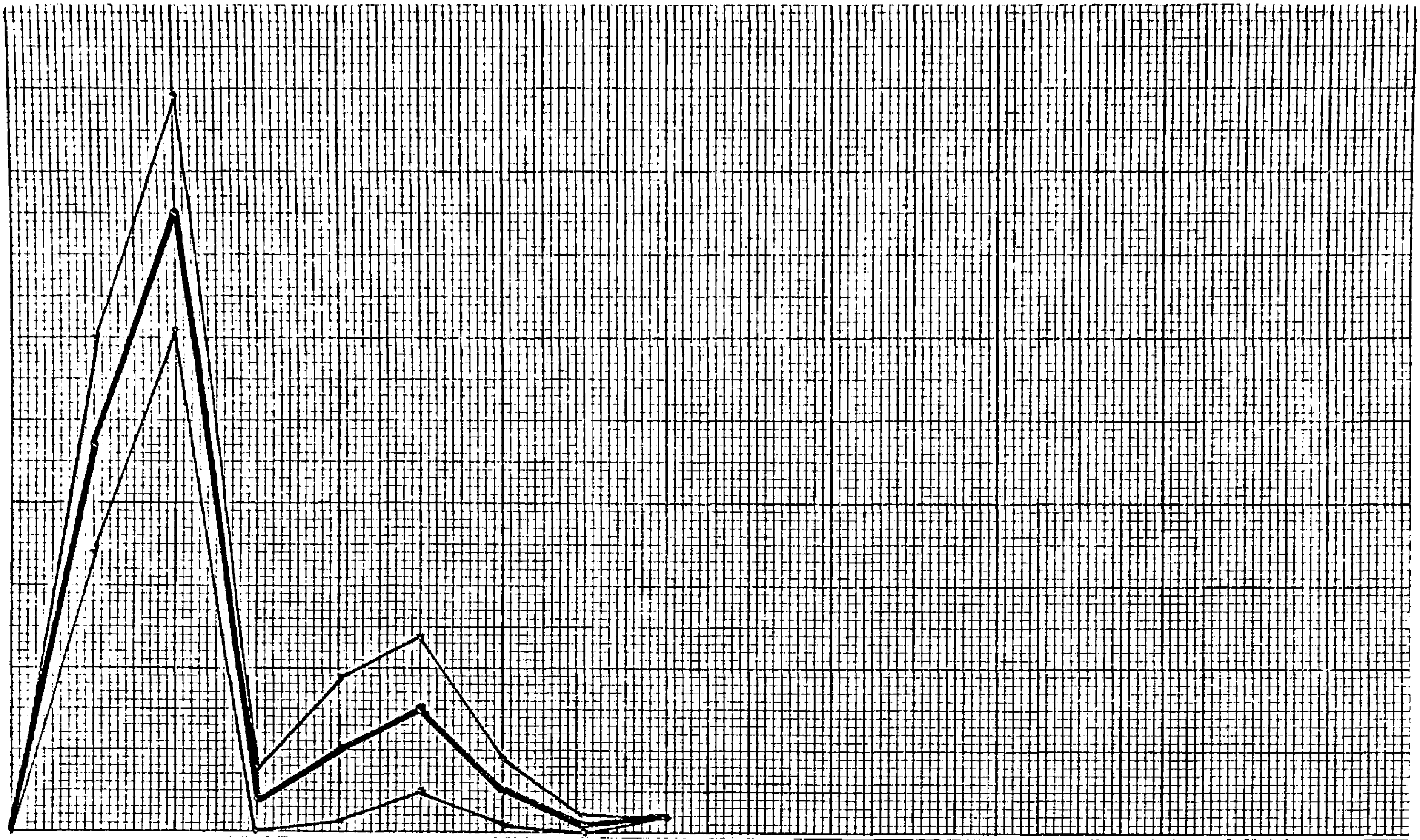

Figure 20. Spectrum Envelope: Group II, Pitch f.

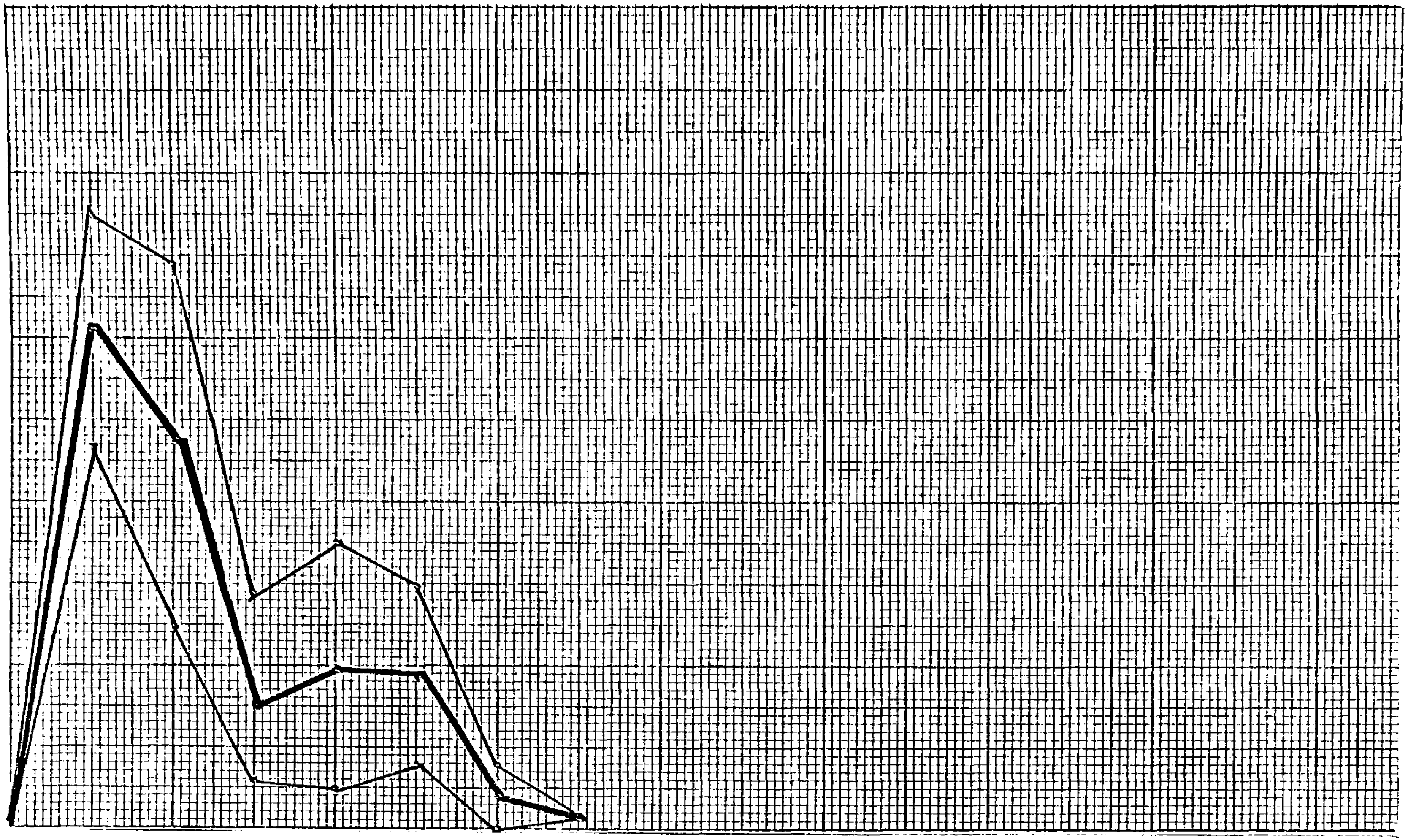

Figure 21. Spectrum Envelope: Group II, Pitch b^{b}.

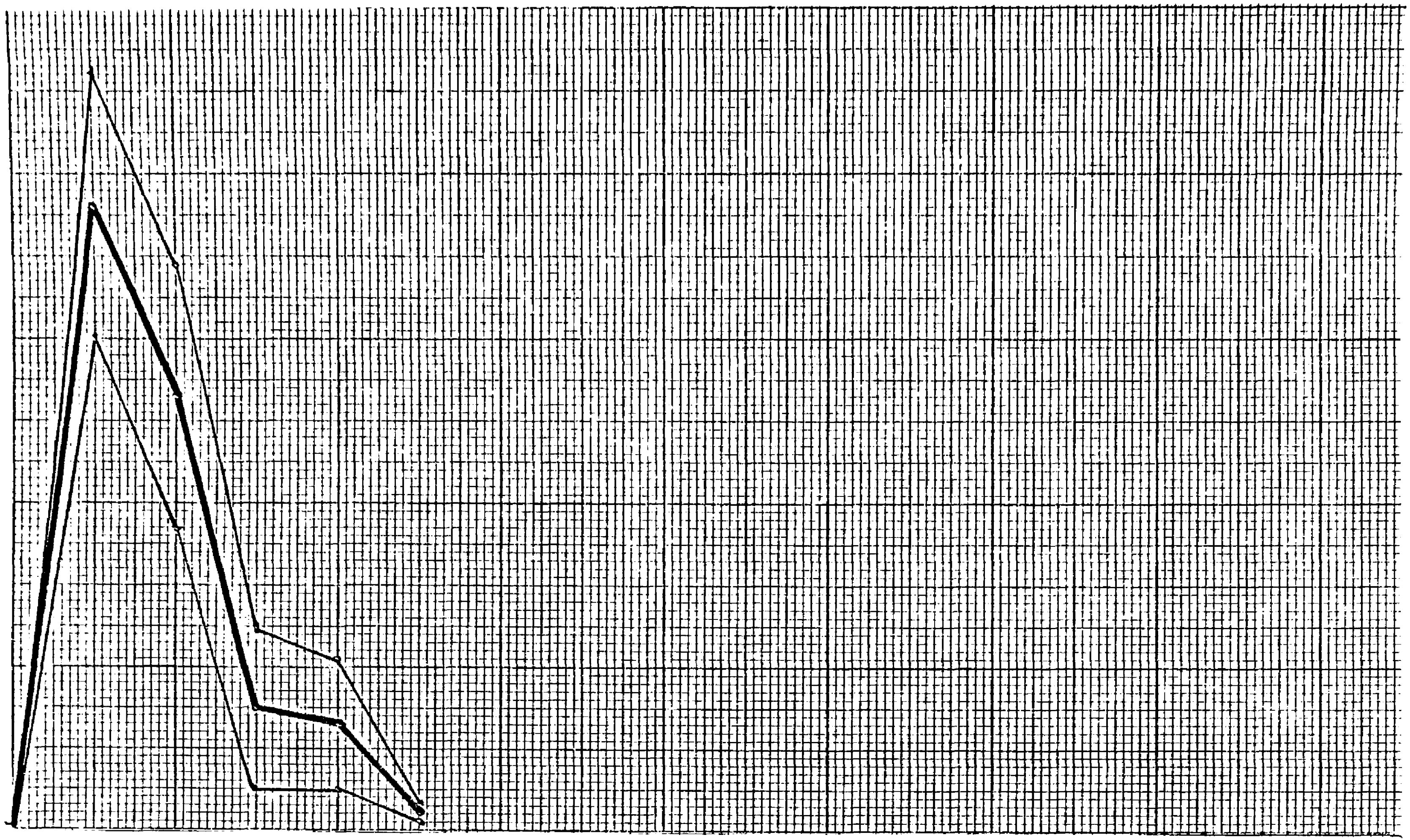

Figure 22. Spectrum Envelope: Group II, Pitch e^b.

Figure 23. Spectrum Envelope: Group III, Pitch d.

Figure 24. Spectrum Envelope: Group III, Pitch g.

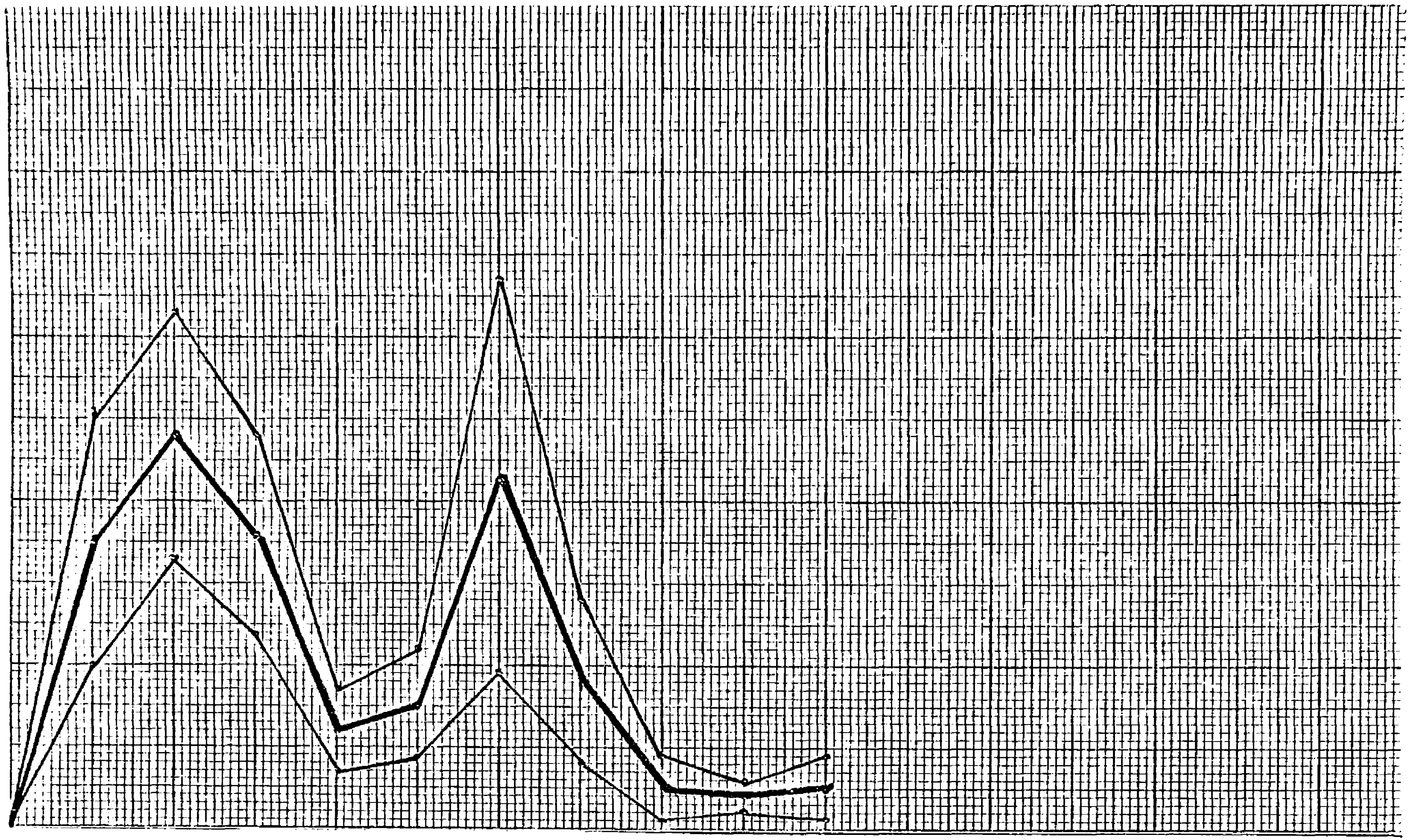

Figure 25. Spectrum Envelope: Group III, Pitch c.

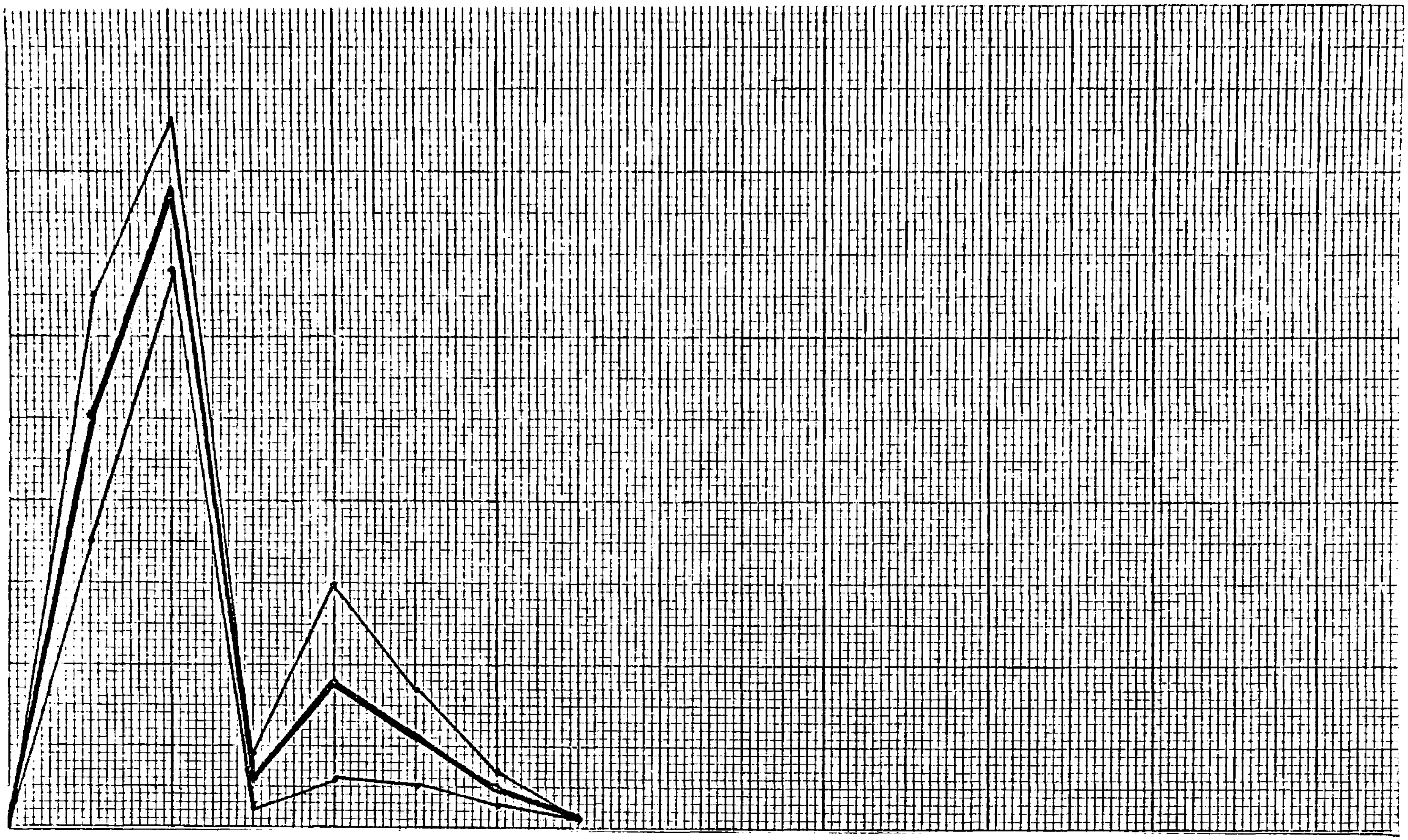

Figure 26. Spectrum Envelope: Group III, Pitch f.

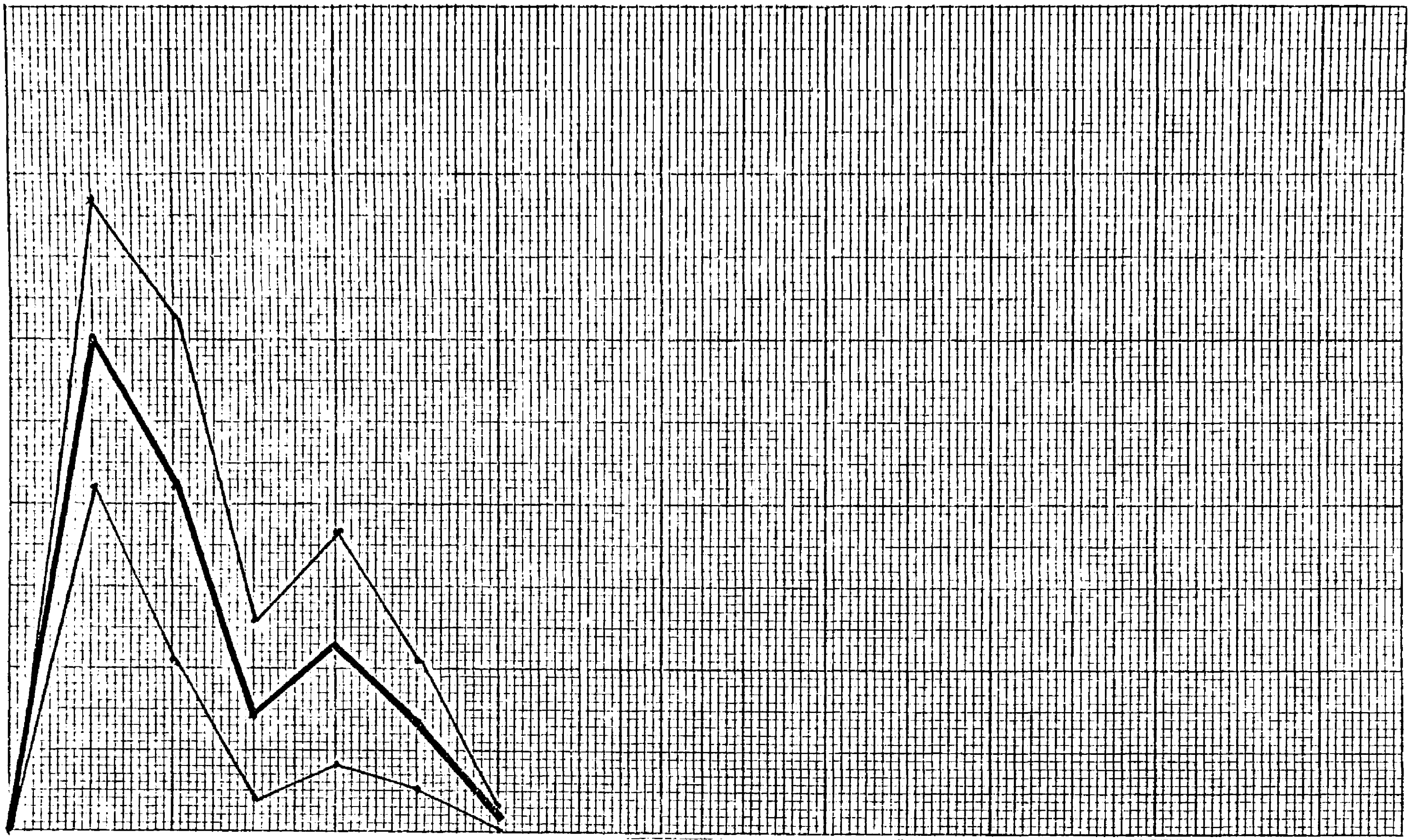

Figure 27. Spectrum Envelope: Group III, Pitch b^b.

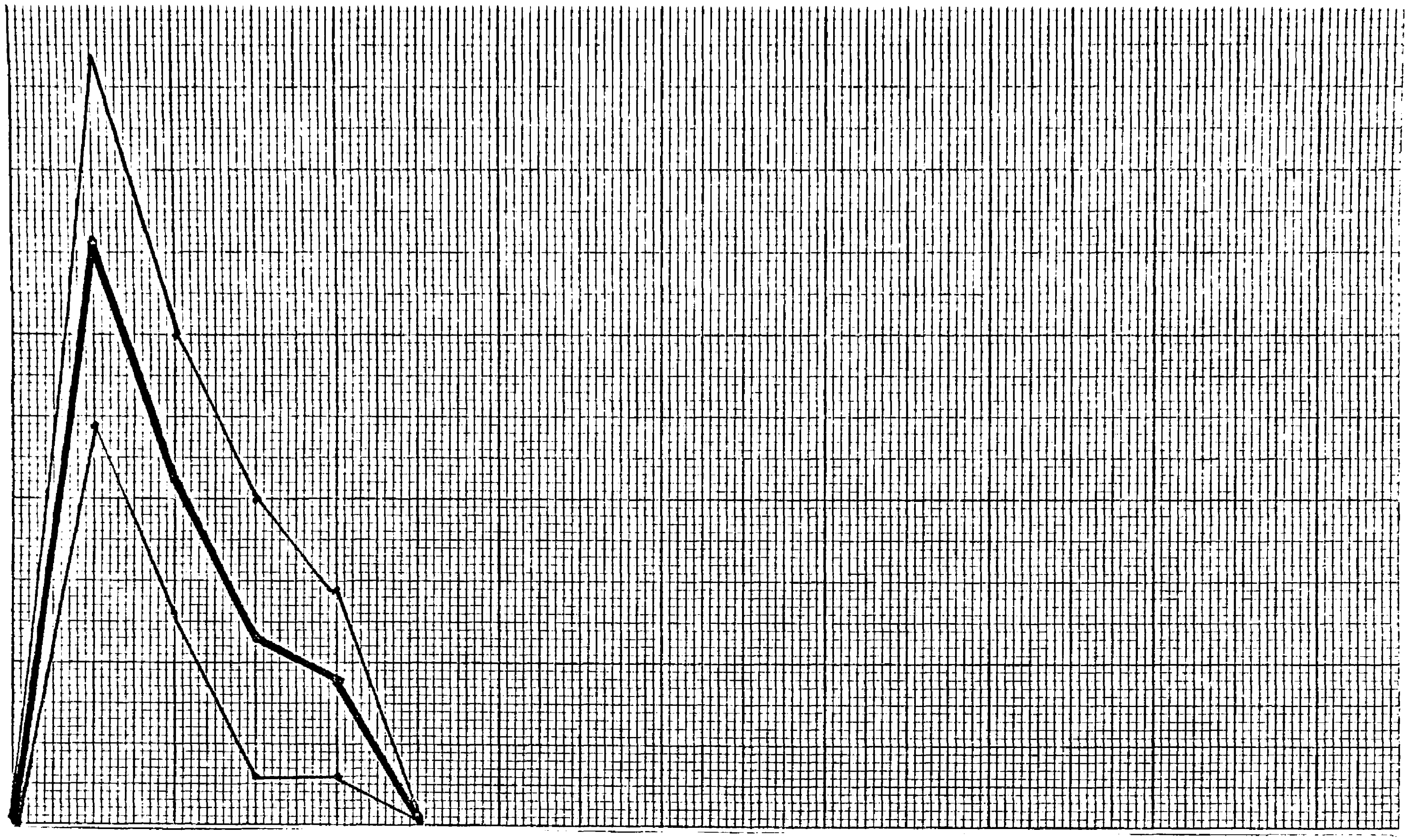

Figure 28. Spectrum Envelope: Group III, Pitch e^b.

Figure 29. Spectrum Envelope: Group IV, Pitch d.

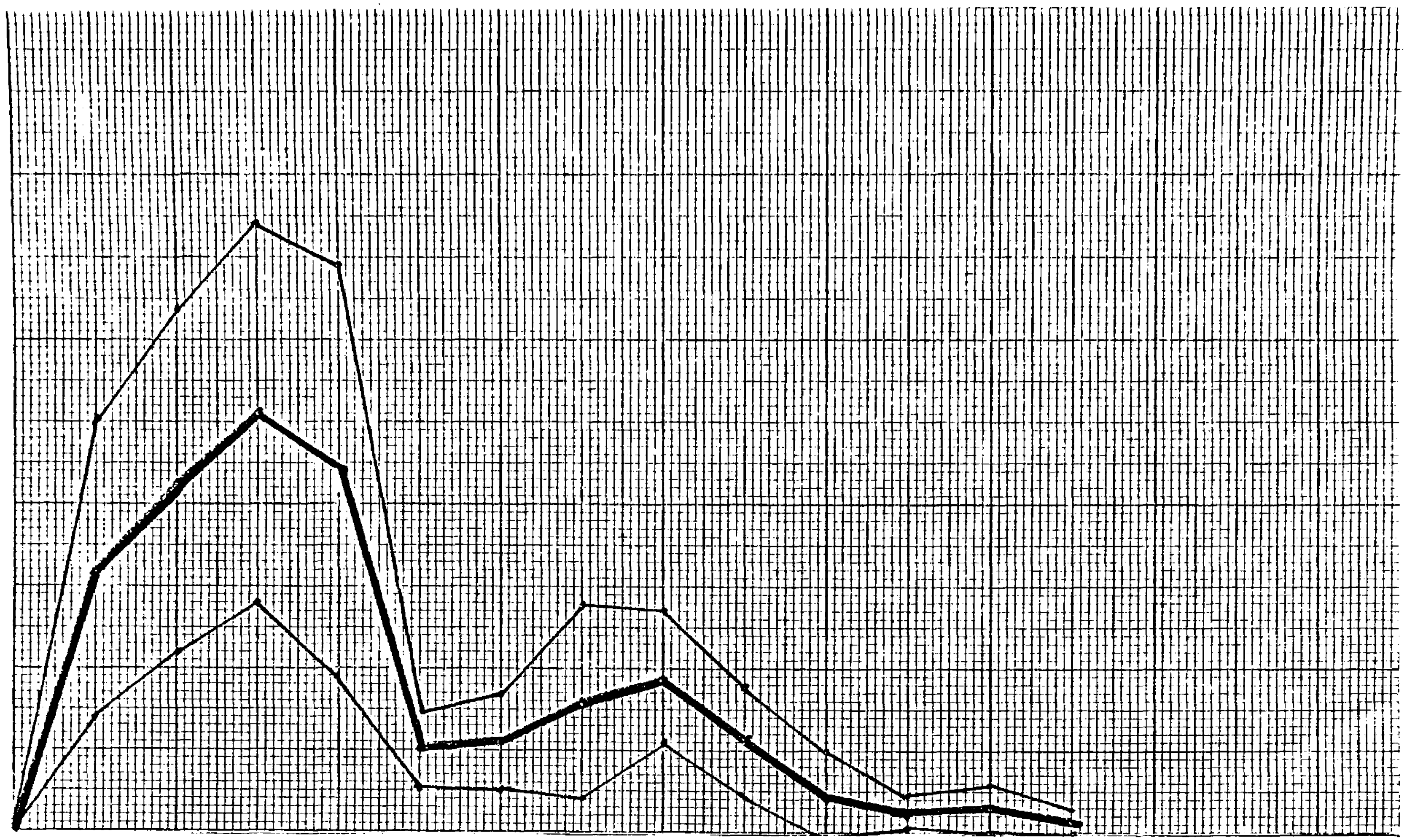

Figure 30. Spectrum Envelope: Group IV, Pitch g.

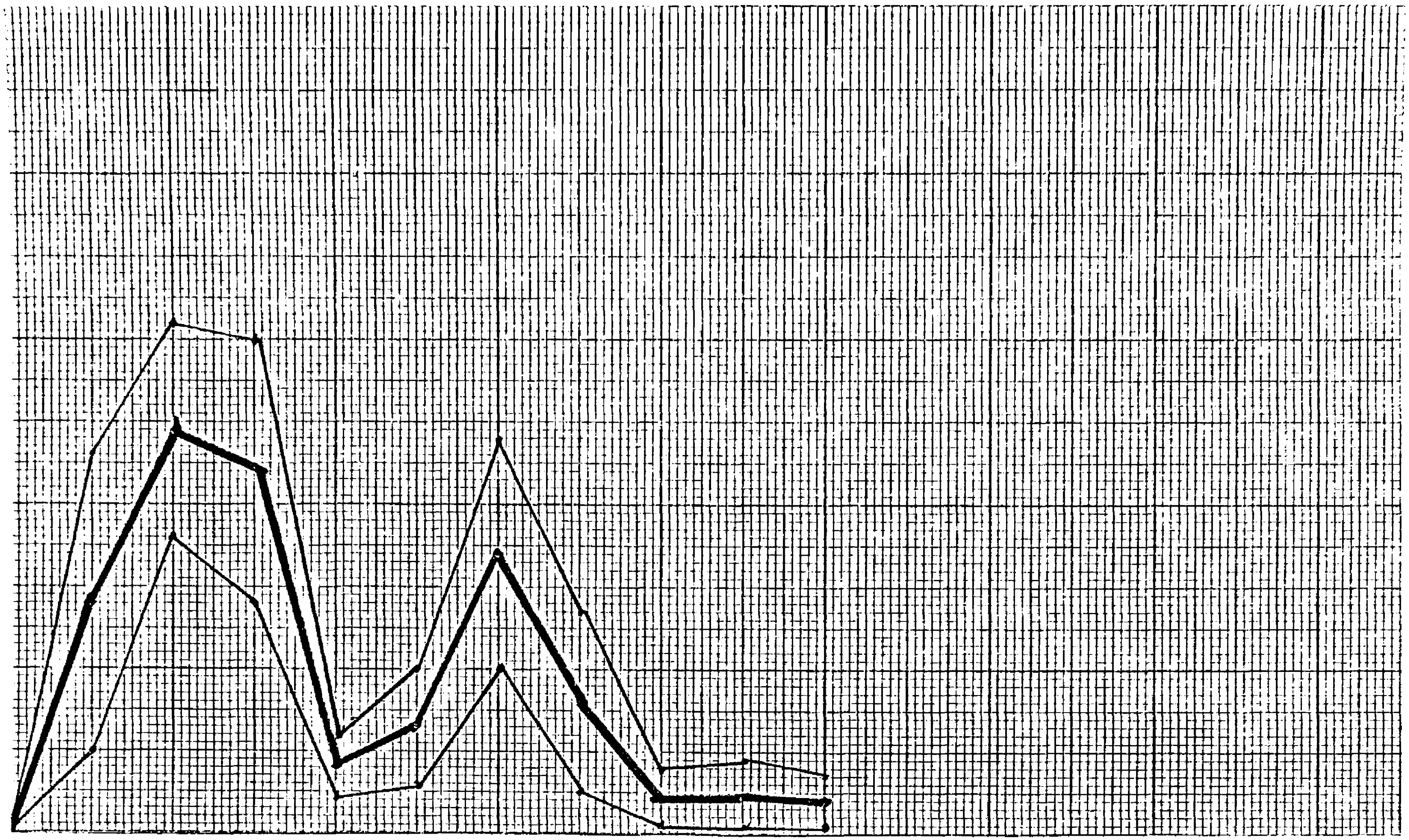

Figure 31. Spectrum Envelope: Group IV, Pitch c.

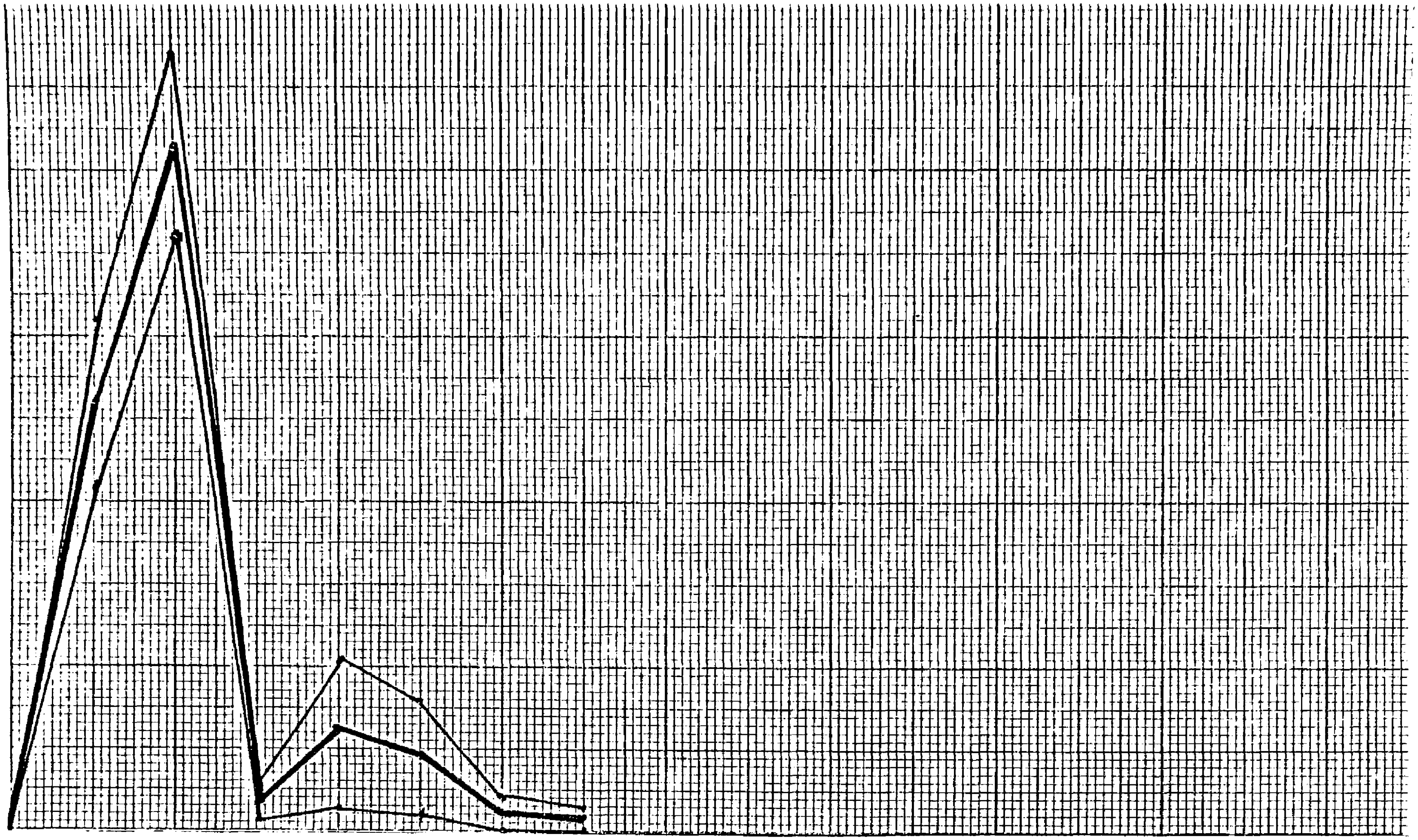

Figure 32. Spectrum Envelope: Group IV, Pitch f.

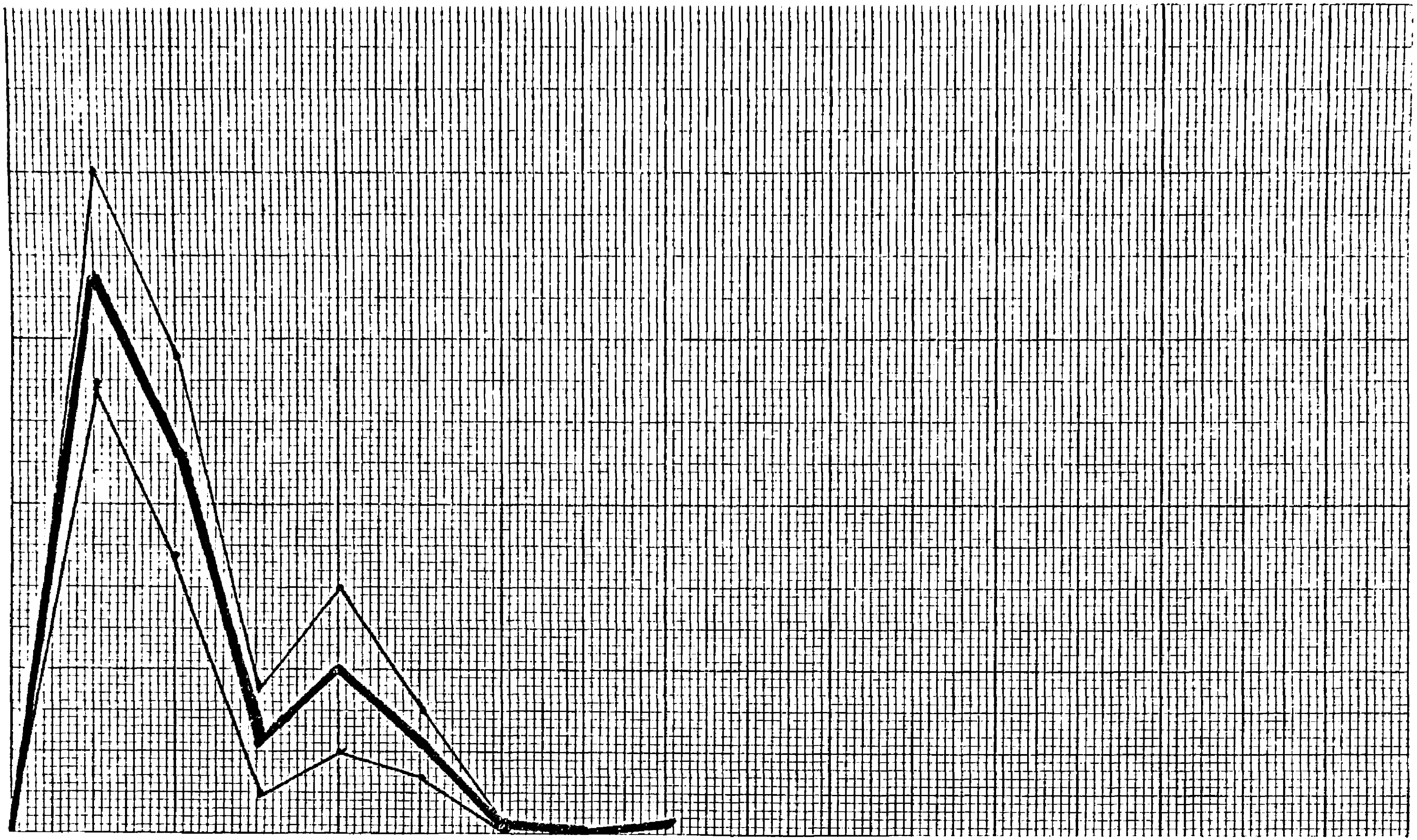

Figure 33. Spectrum Envelope: Group IV, Pitch b^b.

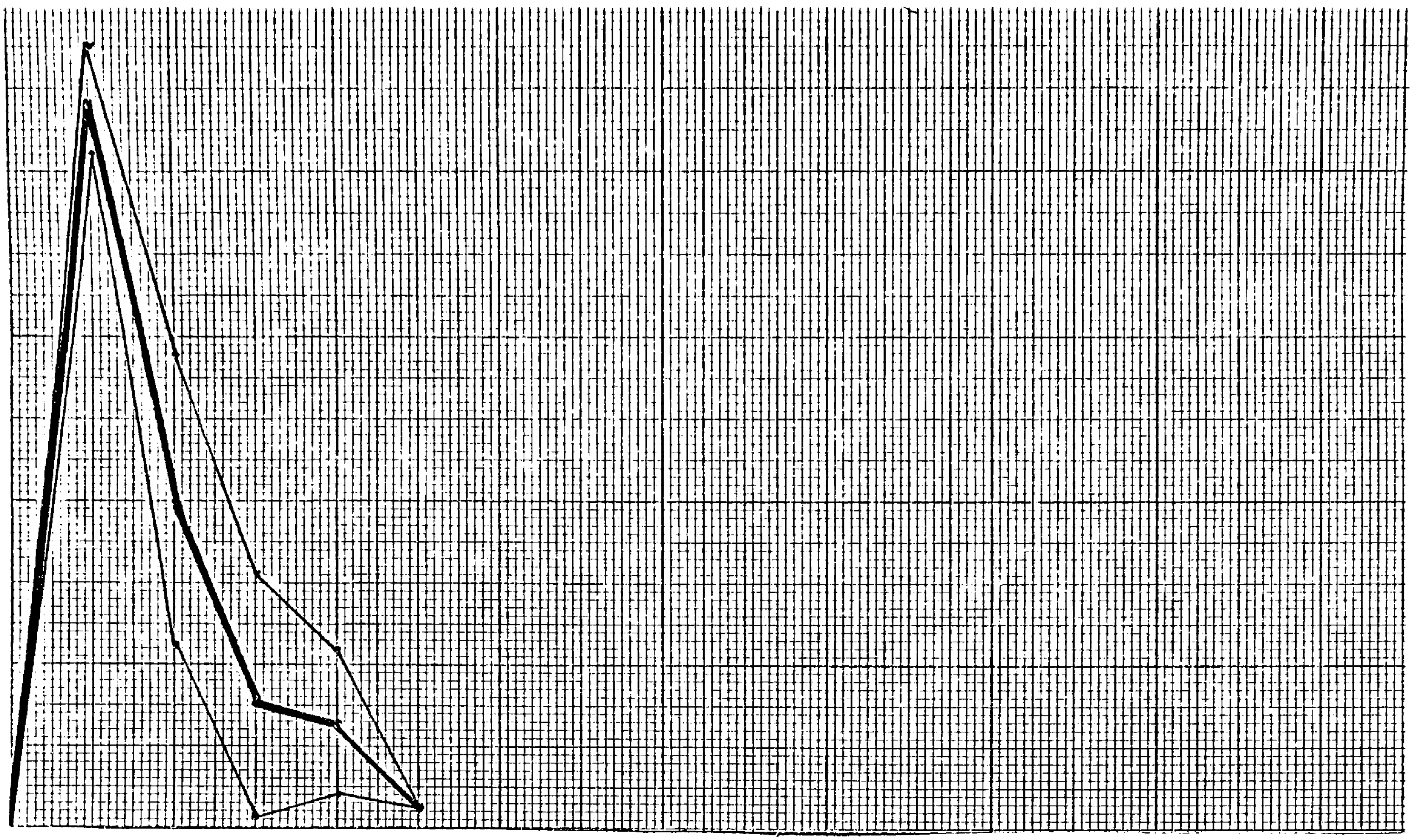

Figure 34. Spectrum Envelope: Group IV, Pitch e^b.

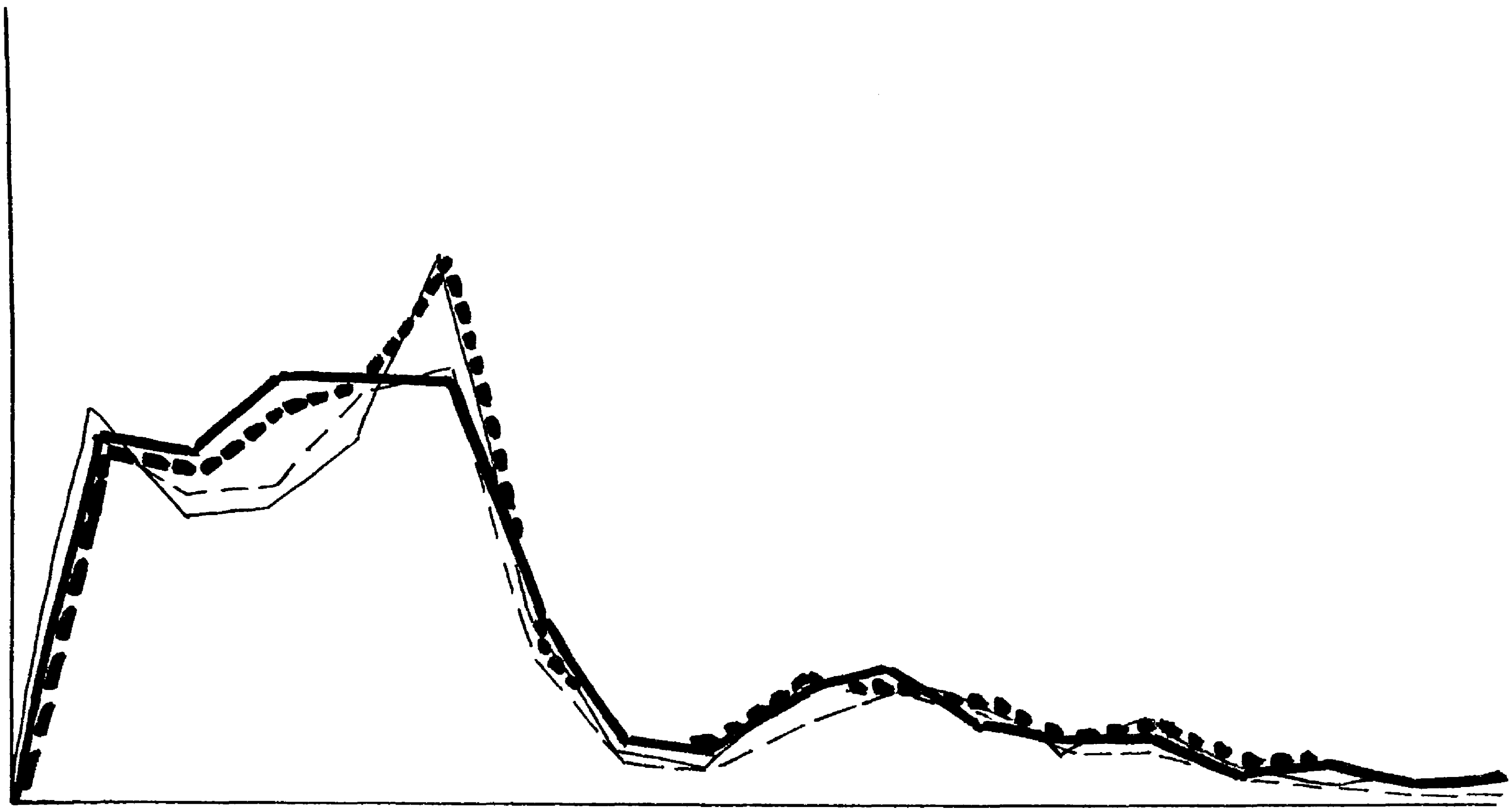

Figure 35. Grand Spectrum Envelope: Pitch d.

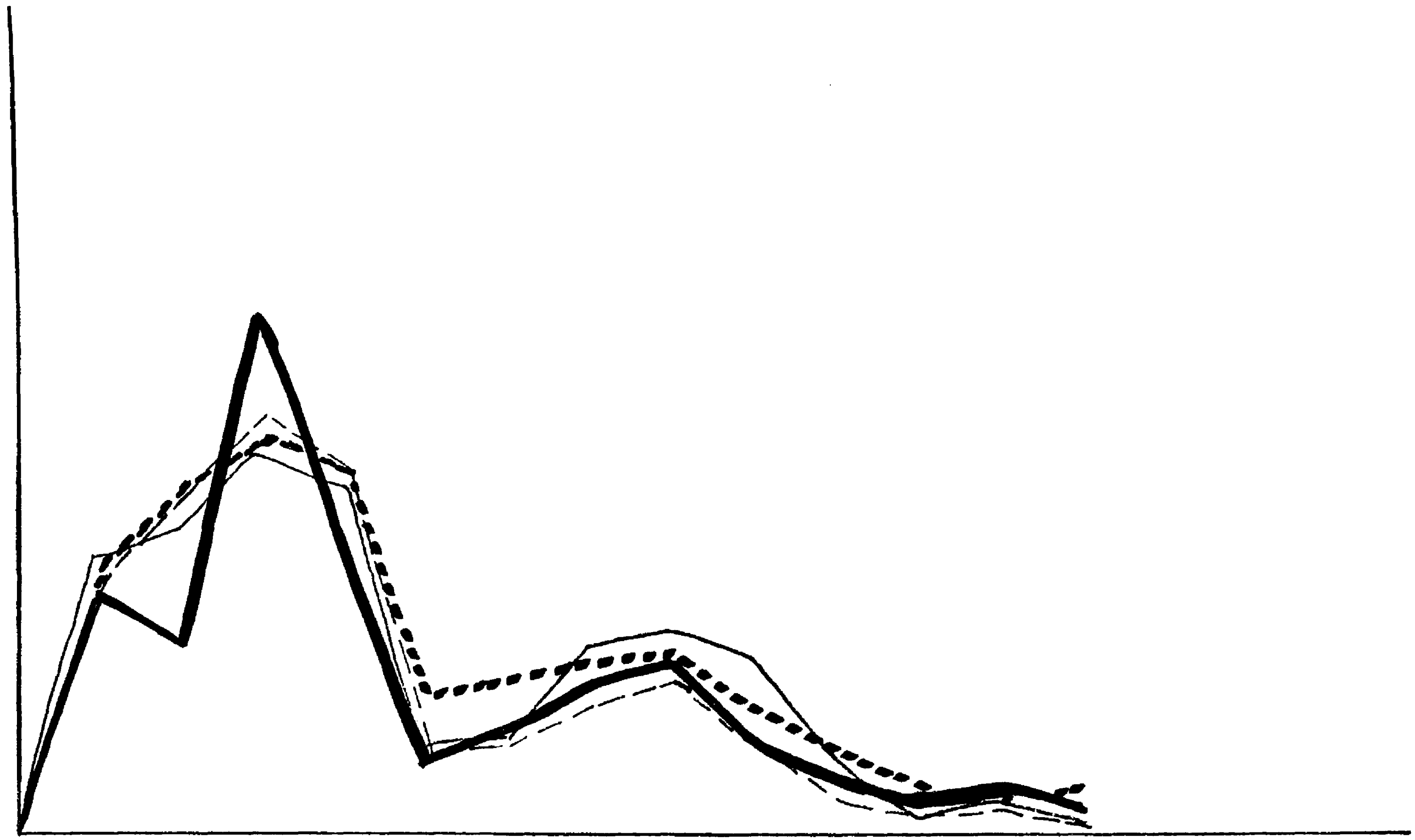

Figure 36. Grand Spectrum Envelope: Pitch g.

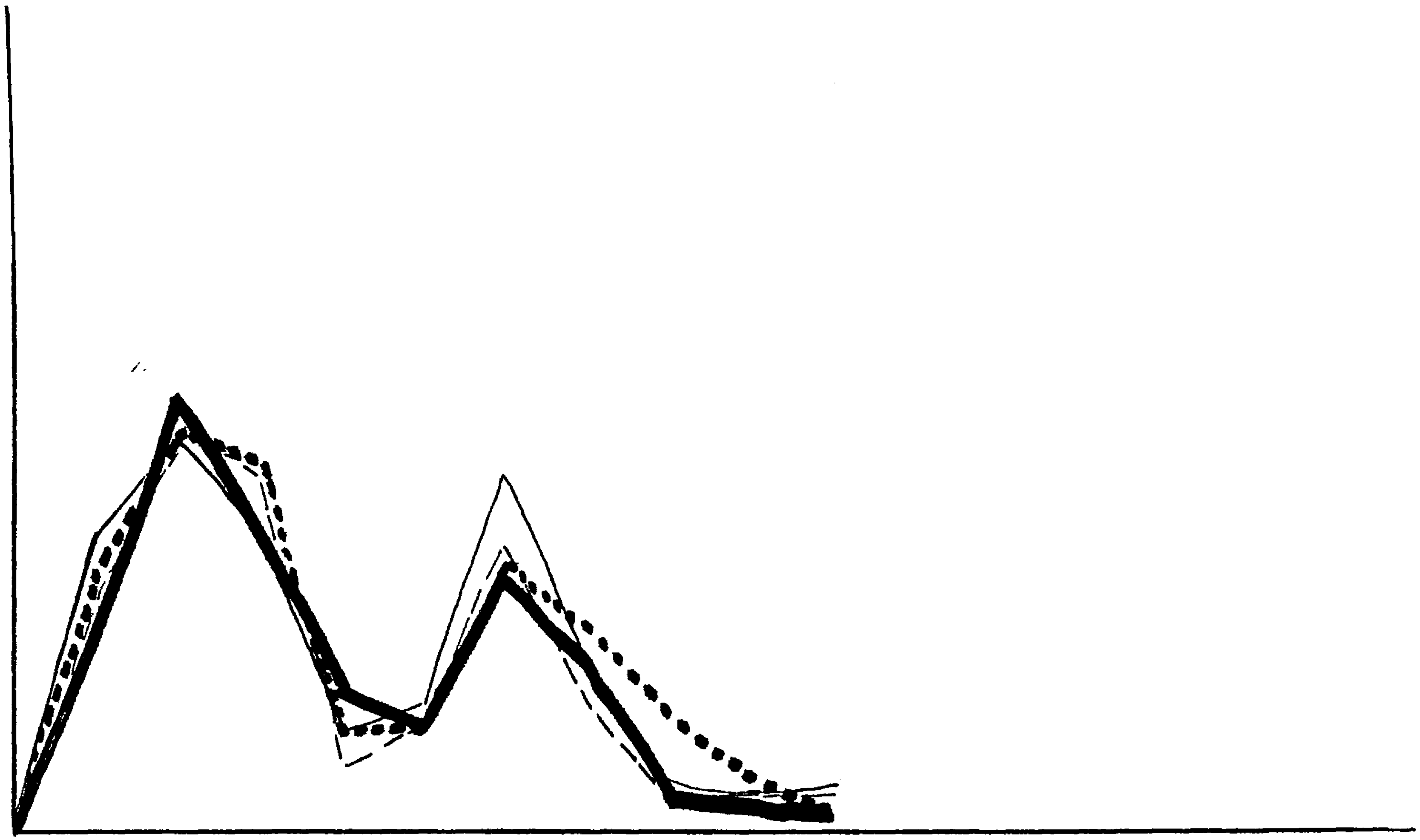

Figure 37. Grand Spectrum Envelope: Pitch c^1.

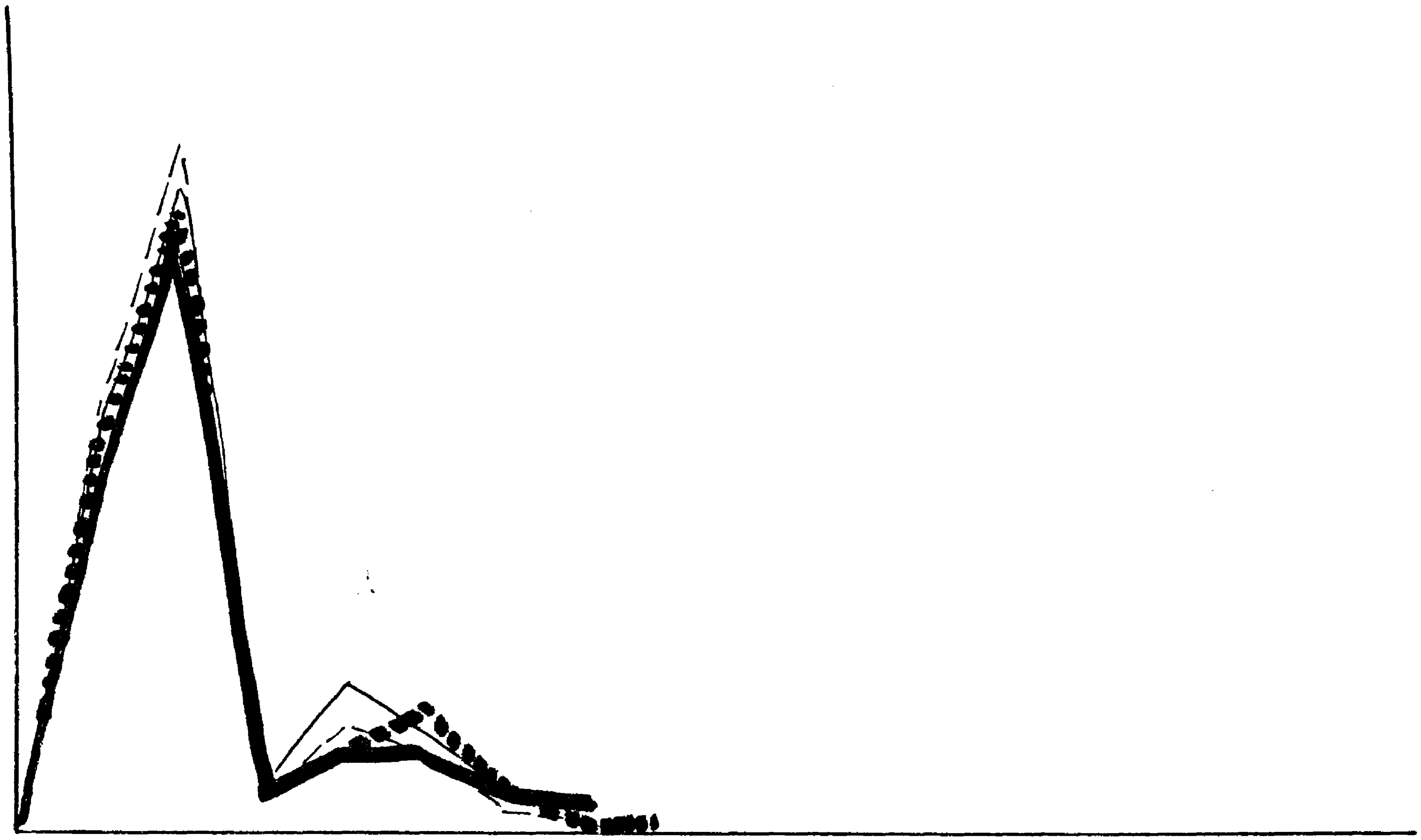

Figure 38. Grand Spectrum Envelope: pitch f^1.

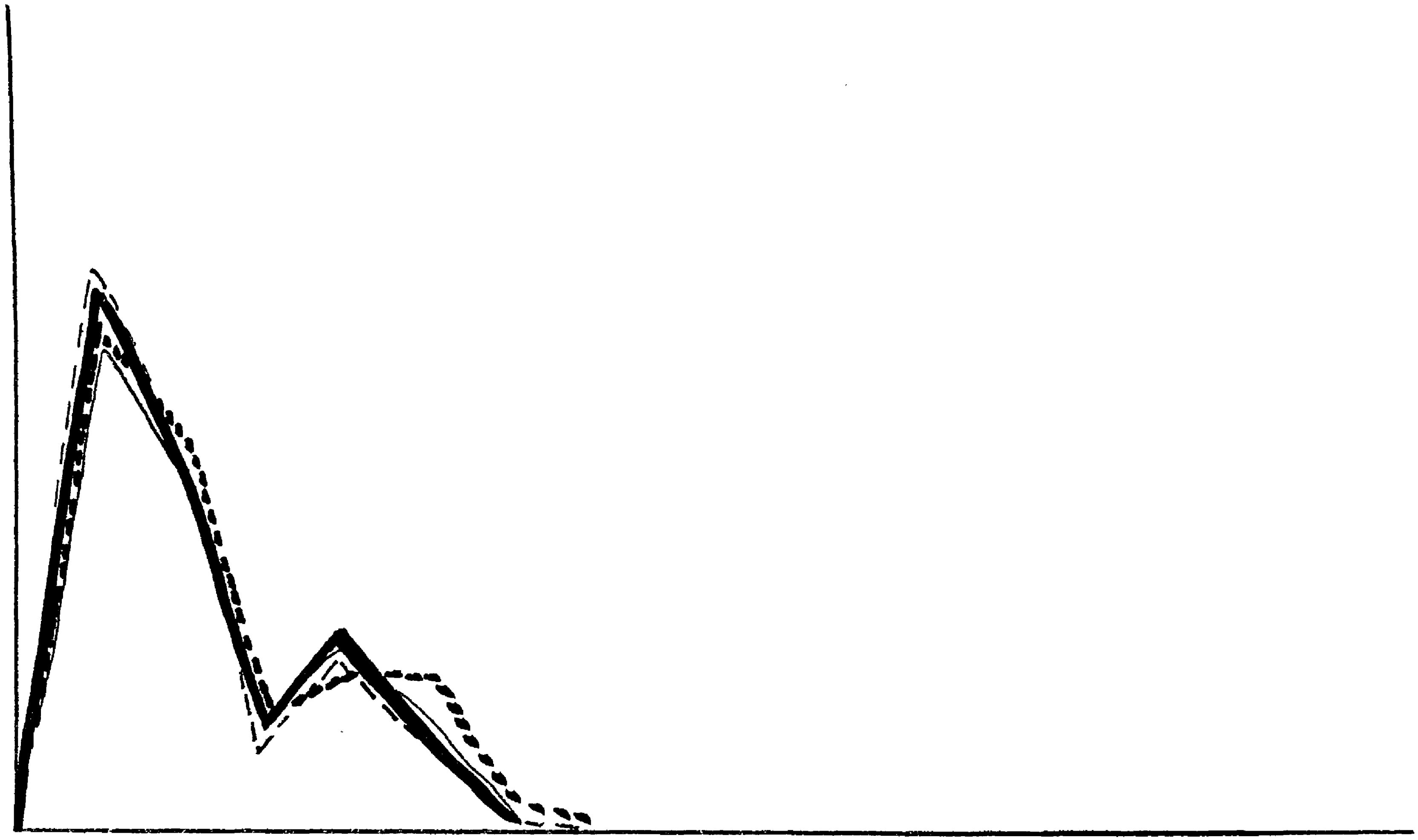

Figure 39. Grand Spectrum Envelope: pitch b^{b^1}.

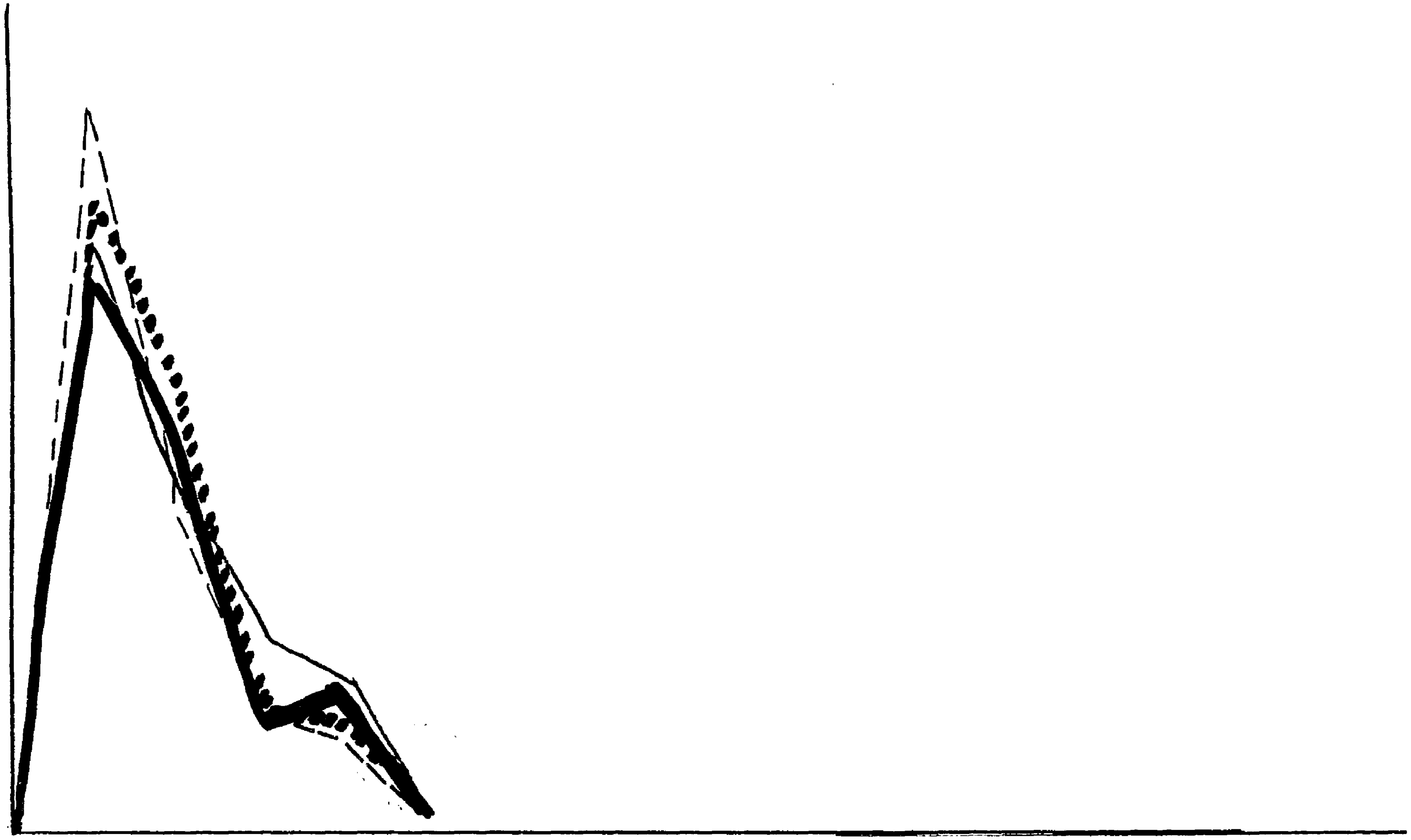

Figure 40. Grand Spectrum Envelope: pitch $e^{b^{2}}$.

statistical analysis. The reed demonstrates relatively little deviation from the mean and remains well within the standard deviation. Here only 25 per cent of the data points fall outside the limits of the standard deviation. Reeds which were evaluated as being less than good exhibited a generally less predictable harmonic picture. For example, the extremely poor tonal quality of reed number 3 is clearly demonstrated in the spectrum of the pitch c^1 (Table 57). The comparison between the tonal spectrum and the statistical averages of the group demonstrates an extreme variation from the normal with 66 per cent of the data points falling outside the limits of the standard deviation. The shape of the envelope also exhibits an eccentric pattern. Pitch g of reed number 10 (Table 58) provides an additional example of the relationship between the statistical analysis and the subjective interpretation of the playing quality of the reed. This is a notably poor reed and is demonstrated by the analysis of the tonal spectrum of this pitch. The fact that 76.9 per cent of the data points fall outside the limits of standard deviation clearly supports the subjective evaluation of the reed's quality. Individual reeds considered to be deficient have an incongruous relationship of the formants due to either a disproportionate weighting of the size and intensity of the formant structure or the unpredictable or eccentric shape of the harmonic series of the pitches. These poorer reeds were often ones in which the individual spectrum envelopes have no dominating peak or formant. As a result, the reed becomes indecisive as to its mode of vibration. The insecure areas of intensity create a kind of conflict in the playing response of the reed reflected as a lack of stability and control.

TABLE 55

SPECTRAL VARIANCE, REED NUMBER 1

Reed	Mean	Variance	Standard Deviation
40	40.6	-0.6	12.4
33	36.9	-3.9	12.5
36	47.4	-11.4	8
77	47.4	29.6	20
63	46.9	16.1	15.4
30	20.5	9.5	11.7
6	7.1	-1.1	3.9
4	6.2	-2.2	5.6
14	11.5	2.5	6.6
24	15.1	8.9	9.2
5	9.3	-4.3	5.1
10	7.3	2.7	5.8
20	7.4	12.6	5.4
7	2.9	4.1	1.7
8	3.9	4.1	2.3
2	1.7	0.3	1.0

TABLE 56

SPECTRAL VARIANCE, REED NUMBER 43

Reed	Mean	Variance	Standard Deviation
43	43.6	-0.6	5.6
37	31.4	5.6	13.4
22	32.3	-10.3	12.3
50	41.6	8.4	27.6
58	60.8	-2.8	11.3
37	21.6	15.4	9.0
11	5	6.0	4.8
1	4	-3.0	5.3
7	11.7	-4.7	7.0
12	13.9	-1.9	6.6
9	11.6	-2.6	7.2
14	6.1	7.9	3.2
19	9.2	9.8	4.8
5	3.9	1.1	2.5
1	2.6	-1.6	1.6
2	1.4	0.6	1.5

TABLE 57

SPECTRAL VARIANCE, REED NUMBER 3

Reed	Mean	Variance	Standard Deviation
35	25.3	9.7	13.6
77	52.5	24.5	12.1
11	35.5	-24.5	18.4
13	17.0	-4.0	7.2
25	12.5	12.3	9.7
52	31.2	20.8	14.6
62	20.3	41.7	18.4
3	4.3	-1.3	2.9
11	3.1	7.9	3.0

TABLE 58

SPECTRAL VARIANCE, REED NUMBER 10

Reed	Mean	Variance	Standard Deviation
68	31.9	36.1	18.2
82	42.6	39.4	20.8
19	51.3	-32.3	23.0
100	44.5	55.5	25.5
7	9.8	-2.8	4.5
17	10.3	6.7	6.3
8	16.0	-8.0	11.9
35	18.8	16.2	8.4
26	10.7	15.3	7.1
22	4.0	18.0	5.7
8	1.8	6.2	2.3
4	3.3	0.7	3.4
3	1.6	1.4	1.1

> Anything that works against the maintenance of oscillation (such as the reduction of the heights of air-column resonance peaks . . . or the misalignment of these resonances so that they fail to set up strongly cooperative oscillatory regimes) requires the player . . . to exert more effort in his playing, so as to provide a combination of increased blowing pressure and greater embouchure tension.[11]

The statistical analysis of tonal quality was obtained by computer analysis due to the large number of data points which resulted from the spectrum analysis of the reeds. The computer, by executing the ANOVA analysis package, provided information regarding a comparison of reeds within each experimental group and among the four groups. The comparison of reeds within each group was primarily made through the application of the mean and standard deviation values. These values were transposed into graph form to produce the Spectrum Envelopes which graphically illustrate the central tendencies of the reeds in each group. The analysis of variance among the four groups of reeds was made by the evaluation of the mean square value. The mean square is expressed as the ratio of the variance of the square of the means among the four experimental groups by the variance of the squared means within each experimental group. The ratio can be expressed as a single value known as the F value which serves as an index. The level of confidence or probability of a type 1 error was set at .05. It was observed that an F value greater than 2.7 generally tended to result in a probability factor which met or exceeded the level of confidence.

The initial results of the statistical analysis indicated that although there exists a slight difference in tonal quality among the

[11] *Ibid*, p. 446.

four experimental reed groups, the difference is not statistically significant. The Analysis of Variance procedure indicated that of a total number of 114 variables, only eleven (9.6 per cent) exhibited a significant difference among the four groups of reeds.

The pitch d had only two partials exhibiting a significant difference: 01T3 (F value = 3.41, PR > F = .0257) and 01T15 (F value = 2.70, PR > F = .0569). The pitch g had four partials exhibiting significant differences: 02T2 (F value = 3.16, PR > F = .0338), 02T5 (F value = 5.01, PR > F = .0045), 02T6 (F value = 2.81, PR > F = .0505), and 02T9 (F value = 4.99, PR > F = .0046). The pitch c^1 had two partials exhibiting significant differences: 03T4 (F value = 4.60, PR > F = .0069) and 03T8 (F value = 5.68, PR > F = .0022). The pitch f^1 had no significant variance of overtones. The pitch b^{b1} had only one significantly different partial: 05T6 (F value = 5.78, PR > F = .0038). The pitch e^{b2} had two partials which were shown to be significantly different: 06T1 (F value = 3.36, PR > F = .0271) and 06T5 (F value = 4.69, PR > F = .0308). (The complete observations of the Analysis of Variance are found in the computer printouts in Appendix B). Under these conditions, the null hypothesis was accepted.

One reason that the statistical analysis of the mean values shows such a small difference between the groups lies in the fact that the deviation of the quality of the reeds within each group is relatively great. This large degree of variability within each group, which was illustrated earlier, results in a kind of overlapping of the data around the mean value which tends to obscure any differentiation which may exist between the groups.

This variability which is observed within each of the experimental groups of reeds is inherent in the reedmaking process and can be attributed to factors such as: the variability in the quality and texture of the cane, the variability of the gouge contour (as the different kinds of cane react differently to the gouging mechanism), and the variability inherent in the scraping process. The complex interrelationship between the cane, the gouge, and the scrape is described in a treatise by the bassoonist, Don Christlieb:

> Obviously more complicated than a single reed, one blade of a double reed must bear a relationship to the other. Gouging the cane with more or less respect to the natural radius of the cane tubing gives us our inside radius. Like the single reed we strip the outer crust giving us our outside radius. By forming the cane around the mandrel [staple] we subject these two radii to still another radius. Scraping in the "lay" following a contour predetermined by our experiences, we work the outside radius inward toward the inside radius. The crowning demand is that the contour common to the two blades must be worked in, blind, without seeing much more than the outside surfaces.[12]

Another reason for the lack of significant differences between the tonal qualities of the reeds is found in the formant theory which asserts that any instrument has a characteristic sound which results from characteristic overtone patterns, formants, in a tone's spectrum envelope. These characteristic regimes of overtone patterns override the most extreme variations in timbre making the instrument a dominant factor in the overall perception of tone quality.

The analysis of the mean tendencies (from which the F values are derived) of each overtone for each pitch on each reed is a purely quantitative evaluation. The consideration of the measurement of standard deviation allows for a more qualitative evaluation of the

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[12]Don Christlieb, Notes on the Bassoon Reed: Machinery, Measurement, Analysis (Rev. ed., Los Angeles, Calif. by the author, 1966), p. 2.

tendencies and a correlation of the four reed groups. The standard deviation, in describing the variability or deviation from the mean, reflects better the consistency of the reeds as individuals as well as groups. A visual comparison of the standard deviation curves, which are superimposed on the spectrum envelope graphs, illustrates the variability which exists among the four experimental groups (see Figures 11-34). Here the difference can be considered somewhat more significant, particularly from the subjective standpoint of the reedmaker-performer. In practical application, the consistency and predictability of oboe reeds are of the utmost importance to the playing response as well as the tonal qualities of the reeds. On the basis of the subjective evaluations of the playing and tonal qualiies of the experimental reeds, it is noted that the variability or deviation in Groups I and III are markedly less than that of Groups II and VI. More specifically, Group I reeds exhibit less variability than those of Group III. However, the tendency of Group III reeds to be generally darker in tonal quality and more consistent in pitch gives preference to the Group III reeds. The reeds of Group IV also tend to exhibit more consistency in terms of pitch and tonal quality than those of Group II. To further reinforce this subjective correlation among the reed groups, it can be noted from the Experimental Data Forms that of the four experimental reed groups, 50 per cent of the Group I reeds were considered good or very good (numbers 1, 2, 13, 14, 15, and 38). Of the Group II reeds, 25 per cent exhibited marginally acceptable qualities (numbers 17, 29, and 41). Group III reeds included eight reeds, 66 per cent, which exhibited good to excellent playing qualities (numbers 7, 8, 19, 20, 31, 32, 43, and 44).

Of the Group IV reeds, only four or 33 per cent of the reeds exhibited good playing qualities (numbers 22, 24, 34, and 35). The differences among these four groups are reflected in the variability and predictability of the reeds and are demonstrated statistically by the measure of standard deviation. The standard deviation provides a more descriptive and appropriate means of evaluation for the performer since it does allow for a somewhat more qualitative judgment.

The effect of the gouge on the playing qualities of oboe reeds appears subtle but important. The gouge plays a significant role particularly in determining pitch tendency. Its role in determining tone quality is not statistically significant but is important from a subjective standpoint, since the gouge does tend to influence the degree of variability and the consistency of oboe reed quality.

The comparison of the relationships between gouge and shape indicates that the shape has a more audible role in determining pitch and tone quality. The apparent domination of the influence of shaper dimension can be justified by the fact that the two experimental gouge settings varied by as little as .01 mm while the two experimental shaper tips differed by as much as 1 mm. The consideration of these factors illustrates the significant contribution that the gouge and shape make to the overall tonal quality of the oboe reed.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The gouge and shape have been shown to be important factors which influence pitch and tone quality of oboe reeds. The processes by which cane is gouged and shaped then become important factors in defining the playing qualities of the reeds. The processes of gouging and shaping are described in Chapter II. Included in this description is a comparison of gouging machines by Claude F. Reynolds and Sons, Inc., and F. Kunibert Michel which serve to typify two contrasting gouging techniques.

The first technique involves the use of a blade whose cutting edge conforms to a true radius and, when properly positioned in the gouger mechanism, is exposed in a symmetrical fashion. The contour of this blade roughly matches the desired gouge contour of the cane, thus eliminating the need to reverse the direction of the gouge by reversing the cane in the gouger bed. This technique is exemplified by the Reynolds gouging machine.

The second technique involves the use of a blade which is ground with a slightly asymmetrical contour and, when positioned in the gouger carriage, is displaced slightly with respect to the guides. This type of blade mechanism, which is applied in the Michel gouging machine, allows for the primary cutting action to take place on only one side

of the cane surface. This action necessitates the reversing of the cane in the gouger bed during the gouging process so that the cane will have the same gouge contour from the middle toward each side. When this blade is properly positioned, approximately one half of the blade is actually critical to the cutting process.

The study of the influence of gouge and shape on pitch and tone quality put these two gouging techniques into practice. Oboe reeds were made with cane of varying dimensions and the tonal qualities of the reeds were subsequently measured and evaluated. Oboe cane was prepared using two contrasting gouge and shaper settings. The two gouge settings, one thick or strong, the other thin or weak, were achieved through the use of the Michel and Reynolds machines, respectively. The measurements of the thick gouge averaged .024 inch at the center and .018 inch at the shaper edge while the thinner gouge averaged .023 inch at the center and .015 inch at the shaper edge. The two contrasting shape dimensions were produced with shaper tips by Angelo (the medium-narrow, 'A' tip) and Bhosys (wide). At the shaper tip, the Angelo tip measures .273 inch and the Bhosys tip measures .315 inch. The cane was then divided into four experimental groups, each containing twelve cane samples. A total of forty eight experimental reeds were made whose playing qualities were subsequently observed, recorded, and analyzed. The analysis of playing quality was restricted to the parameters of pitch and tone quality and all tests were limited to six selected pitches (d, g, c^1, f^1, bb^1, and eb^2). The analysis of the pitch tendencies of the reeds was made through the use of a Conn strobotuner and the measurement of tone quality was made by a Hewlett-Packard Spectrum Analyzer. Due to the large number of

data points which resulted from the spectrum analysis, the measurements were analyzed by the computer at the Northeast Regional Data Center in Gainesville, Florida, which executed the ANOVA Statistical Analysis System. The ANOVA package provided analysis of tonal quality for each reed within the four groups as well as the Analysis of Variance among the four experimental reed groups.

Conclusions

The results of the study indicate that the pitch and tonal quality of oboe reeds are influenced by both the gouge and the shape of the cane. The overall pitch deviation (based on the reference pitch of a = 440 Hz) of each of the four experimental groups is as follows: Group I = +1.09, Group II = -5.01, Group III = -1.01, and Group IV = -1.79 cents. The influence of the gouge is demonstrated by the sum of the values in each group. The thick gouge (X) exhibited a grand deviation of -3.92 cents, while the thin gouge (Y) exhibited one of -2.80 cents. The influence of the shape is noted by a grand deviation of +0.08 cents with the narrow (n) shape and -6.80 cents with the wide (w) shape. It can therefore be concluded that, on the basis of pitch, the most desirable combination under these conditions would be the thinner gouge combined with the narrow shape. The least desirable combination would utilize the pairing of the thick gouge and wide shape. The null hypothesis was rejected.

The influence of gouge and shape on tone quality was determined by statistical analysis of the mean values of the tonal qualities of the experimental reeds. The statistical analysis indicated that the difference in tonal quality among the four reed groups is slight and

not overall statistically significant. The analysis was based on a .05 level of confidence and indicated that of a total 114 variable points, only eleven (9.6 per cent) exhibited significant differences among the four experimental reed groups. They are as follows: 01T3, 01T5; 02T2, 02T5, 02T6, 02T9; 03T4, 03T8; 05T6; 06T1 and 06T5. One of the principal reasons for this conclusion lies in the great amount of variability of the individual reeds within each group. However, some observations can be made regarding the influence of gouge and shape on pitch and tone quality. With respect to the gouge, the thick gouge (X) tended to produce brighter tonal quality while the thin gouge (Y) tended to produce darker overall tonal quality. With respect to the shape, the narrow shape (n) resulted in brighter tone quality and the wide shape (w) resulted in darker tone quality. These results can be illustrated by a comparison of the spectrum envelope graphs included in the text. Included as part of the spectrum envelope were the graphs of standard deviation which reflect the consistency and predictability of the reed quality. The analysis of the deviation in tonal quality illustrated by the spectrum envelope graphs indicates that reed Groups I and III exhibit slightly more overall consistency than do the reeds from Groups IV and II.

The results of the subjective evaluation of the performing qualities of the individual reeds of each group indicated that: fifty per cent of the reeds in Group I were judged to be very good in quality; twenty-five per cent of the Group II reeds were marginally acceptable; sixty-six per cent of the Group II reeds were considered good to excellent; and thirty-three per cent of the Group IV reeds demonstrated some good qualities. Under these particular conditions, the null hypothesis was accepted.

Since the aspects of reedmaking, performance, and tonal quality are imbued with personal subjectivity, the correlation of these results of the subjective evaluations of the reeds with the above conclusions illustrates the truly significant influences that the gouge and shape exert on pitch and tone quality.

Recommendations

There is a distinct need for more research into the nature, definition, and relationships of tone quality and pitch. The potential for research exists and any additional study would result in a meaningful contribution to the understanding of this fascinating topic. Some areas recommended for additional study would include: a more complete sampling of pitches, the utilization and comparison of different instruments or different performers, a study of the influence of intensity on tone quality, and a detailed spectrum analysis of the reed crow as related to tone quality. Further research is certainly possible with the aid of the computer. There exist numerous additional ways in which the computer can evaluate the data provided in this study. Further analysis of this kind of information would provide new perspectives and approaches which would certainly result in a clearer understanding of the complex relationships which exist between the gouge and shape and their influence on pitch and tone quality of the oboe.

THE INFLUENCE OF GOUGE AND SHAPE ON PITCH AND TONE QUALITY OF THE OBOE

VOLUME II

A Monograph

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Musical Arts

in

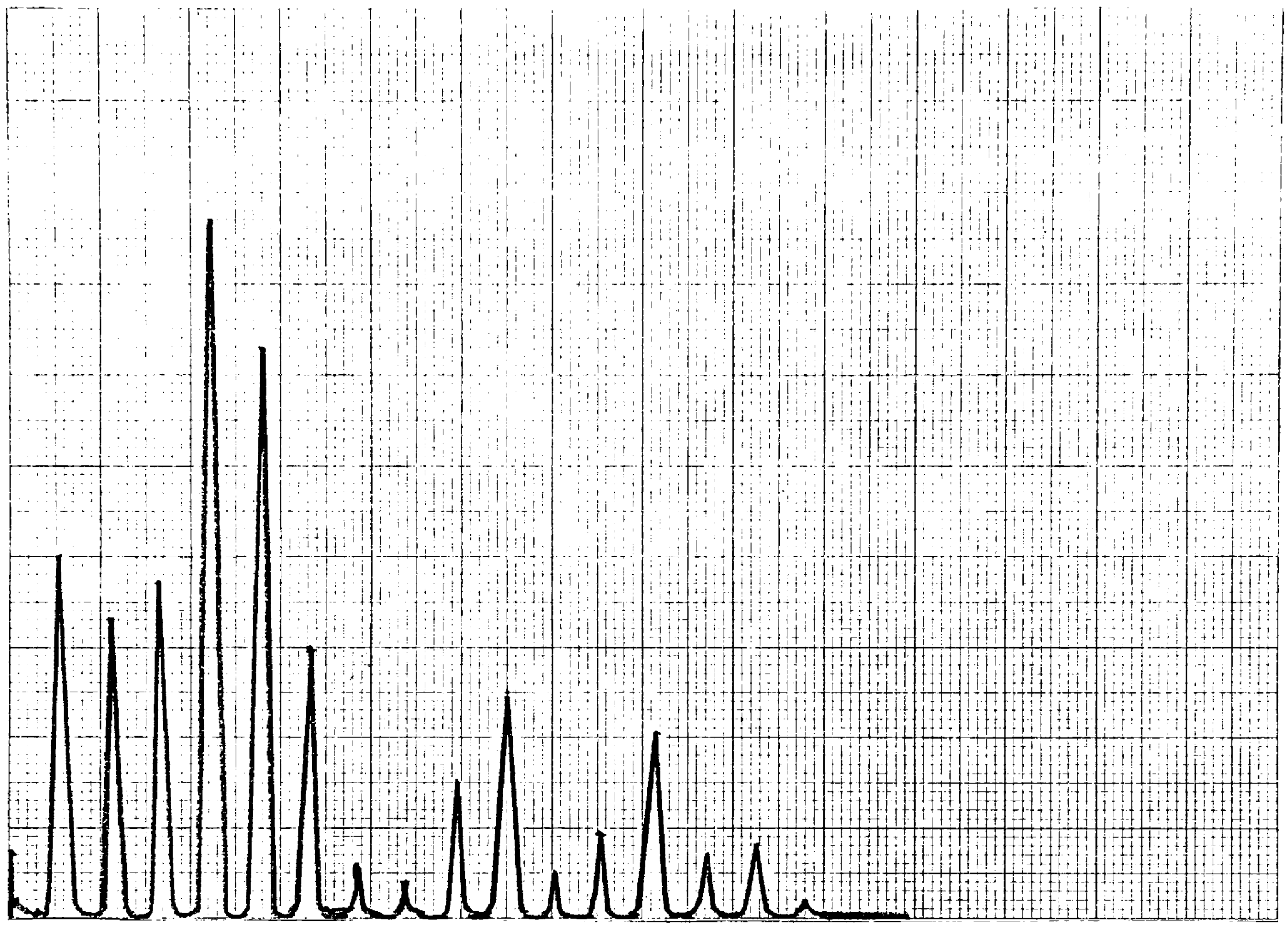
The School of Music

by
Mark Stephen Ostoich
B.M., Louisiana State University, 1972
M.M., Louisiana State University, 1973
December 19, 1980

c. 2

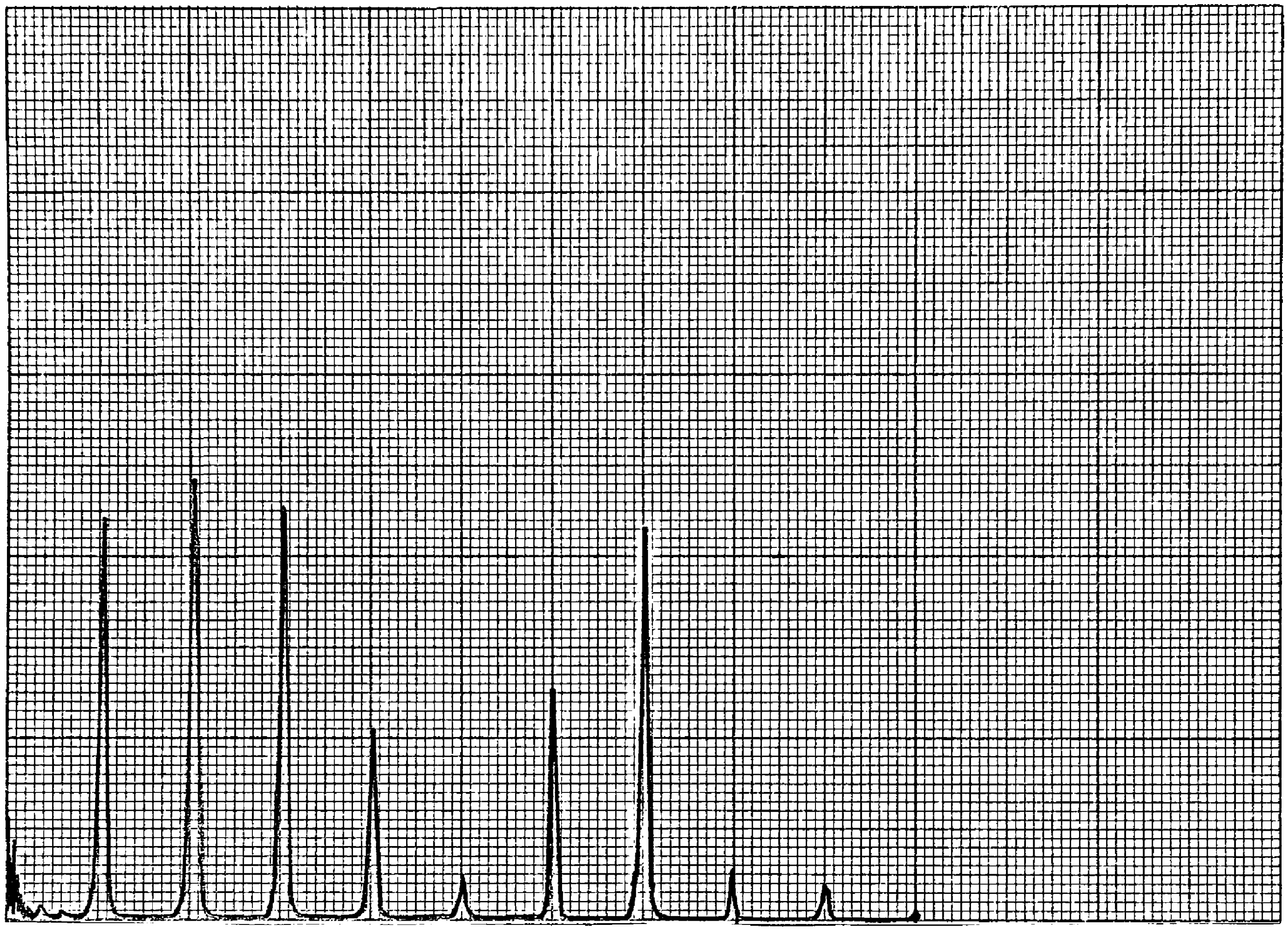
APPENDIX A

SPECTRUM ANALYSIS GRAPHS

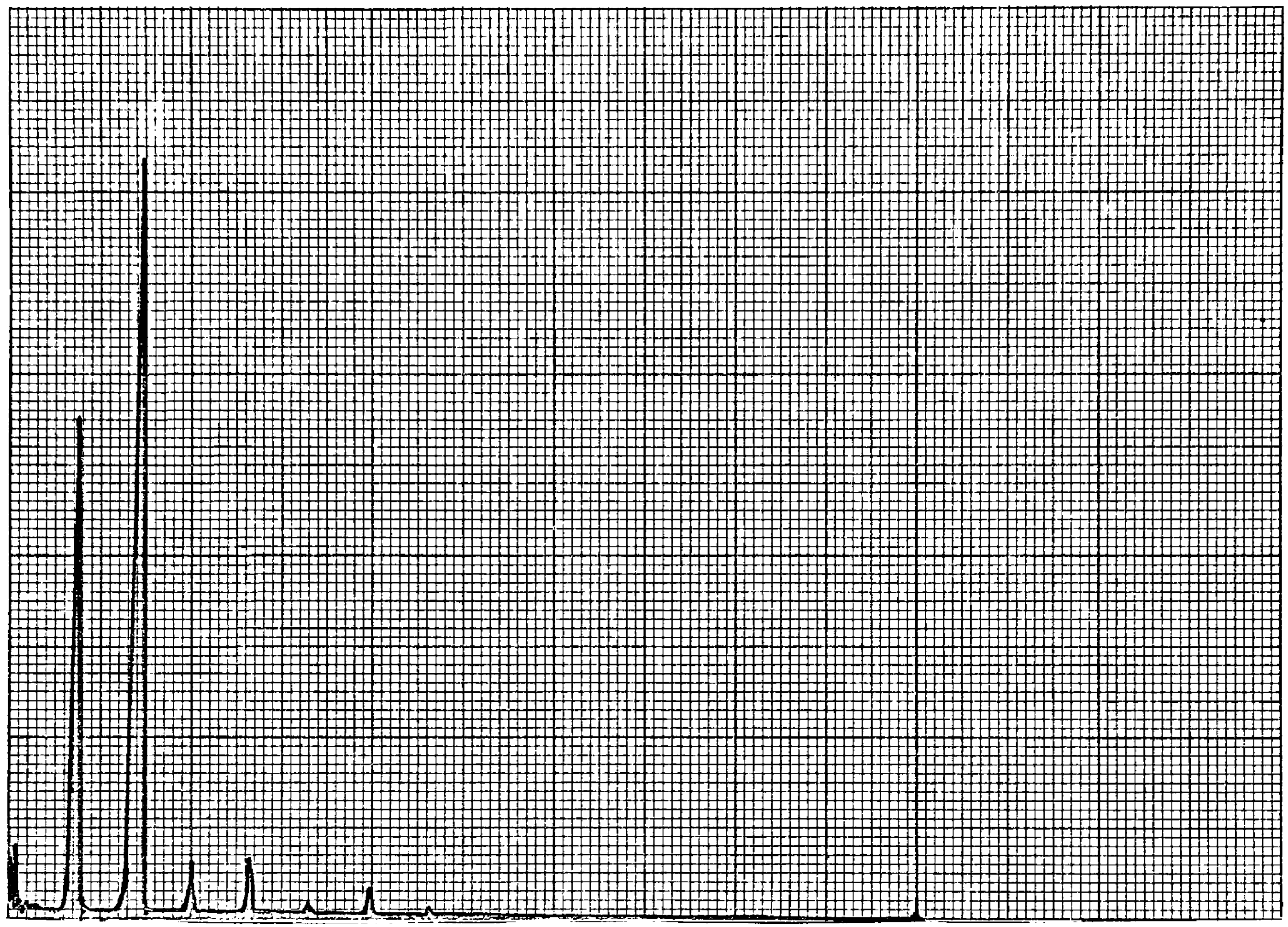


Spectrum Analysis Graph: Group I, Subject Number 1, Pitch d.

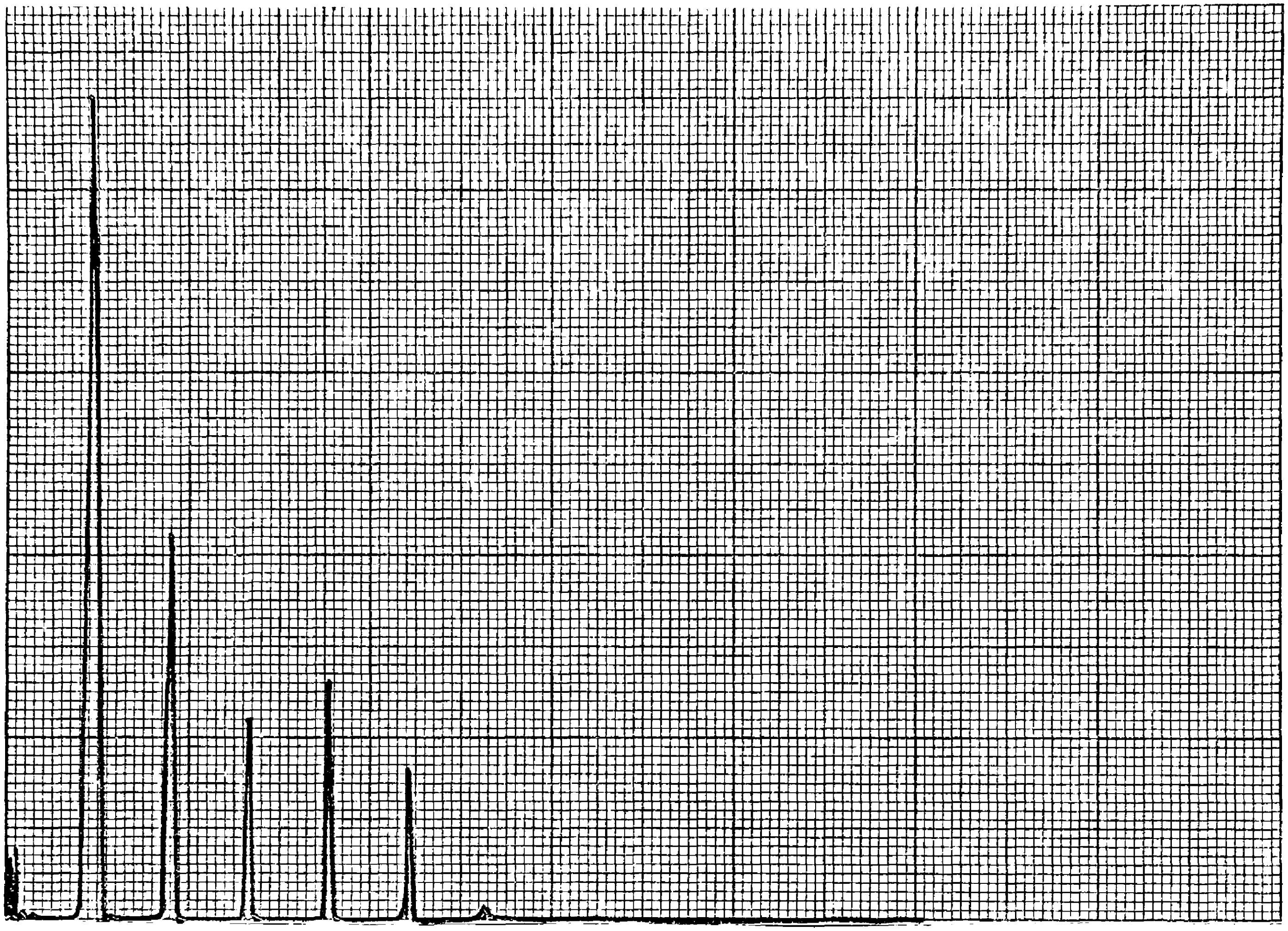
Spectrum Analysis Graph: Group I, Subject Number 1, Pitch g.



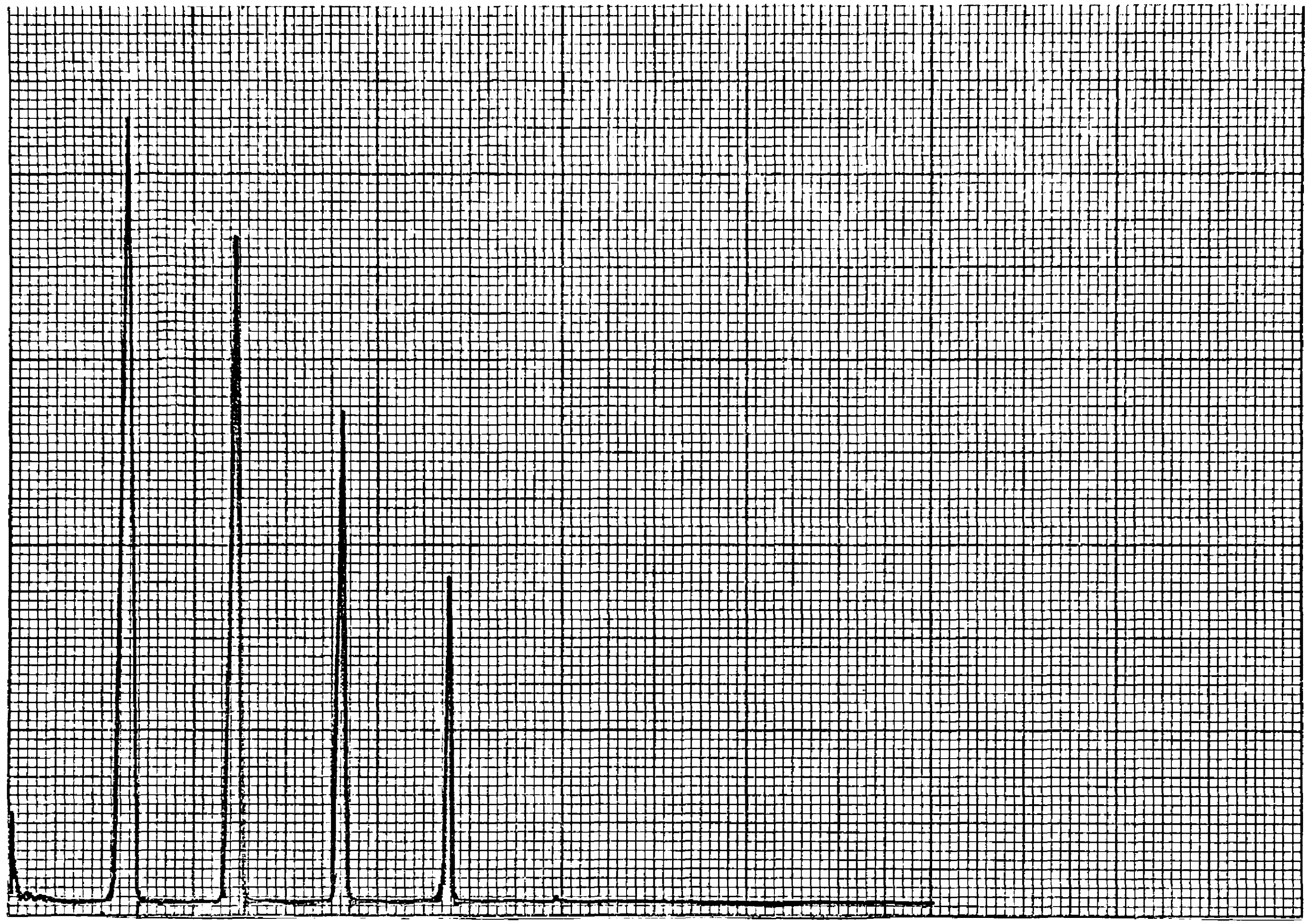
Spectrum Analysis Graph: Group I, Subject Number 1, Pitch c.



Spectrum Analysis Graph: Group I, Subject Number 1, Pitch f.

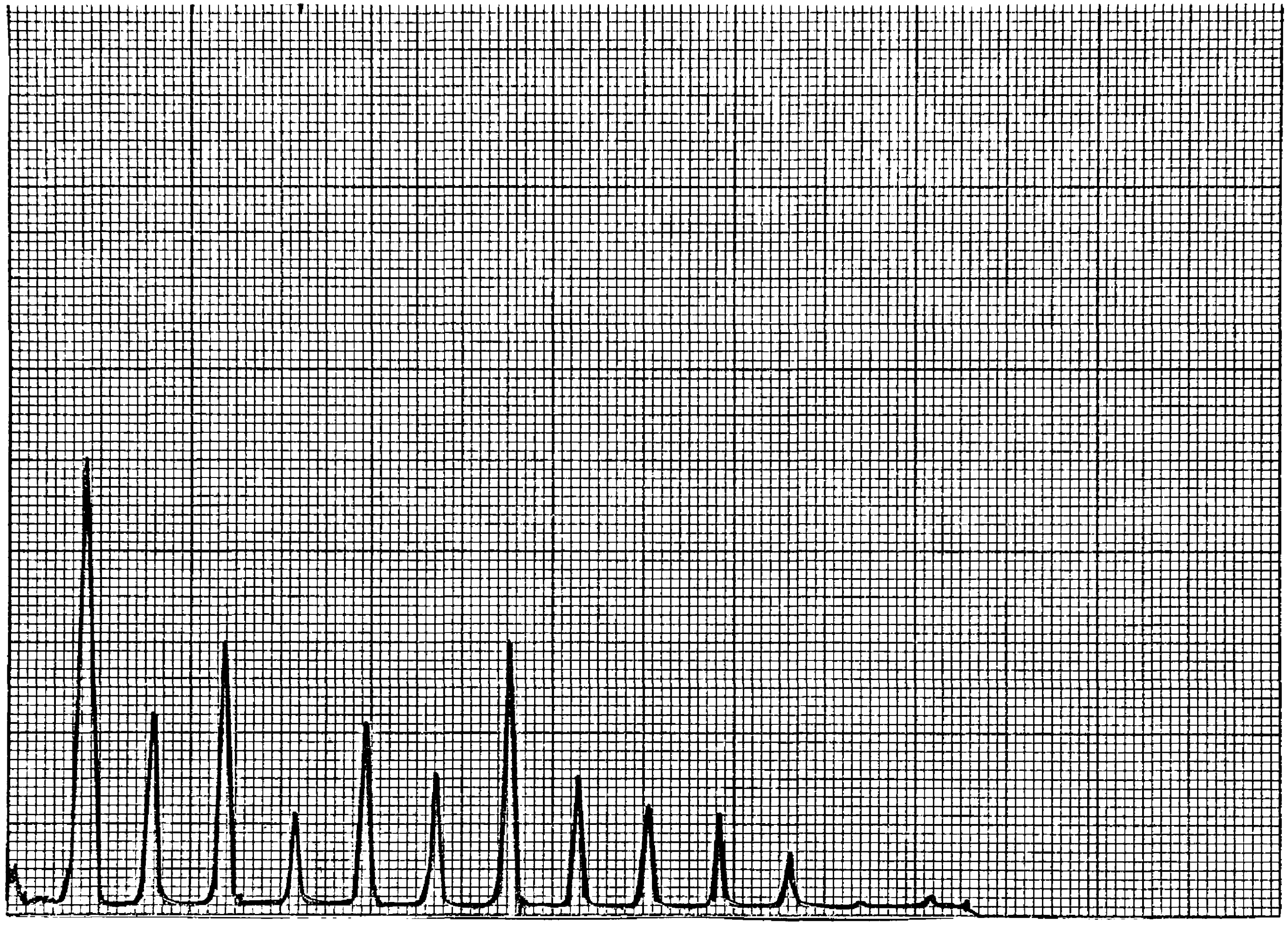


Spectrum Analysis Graph: Group I, Subject Number 1, Pitch b^{b}. .

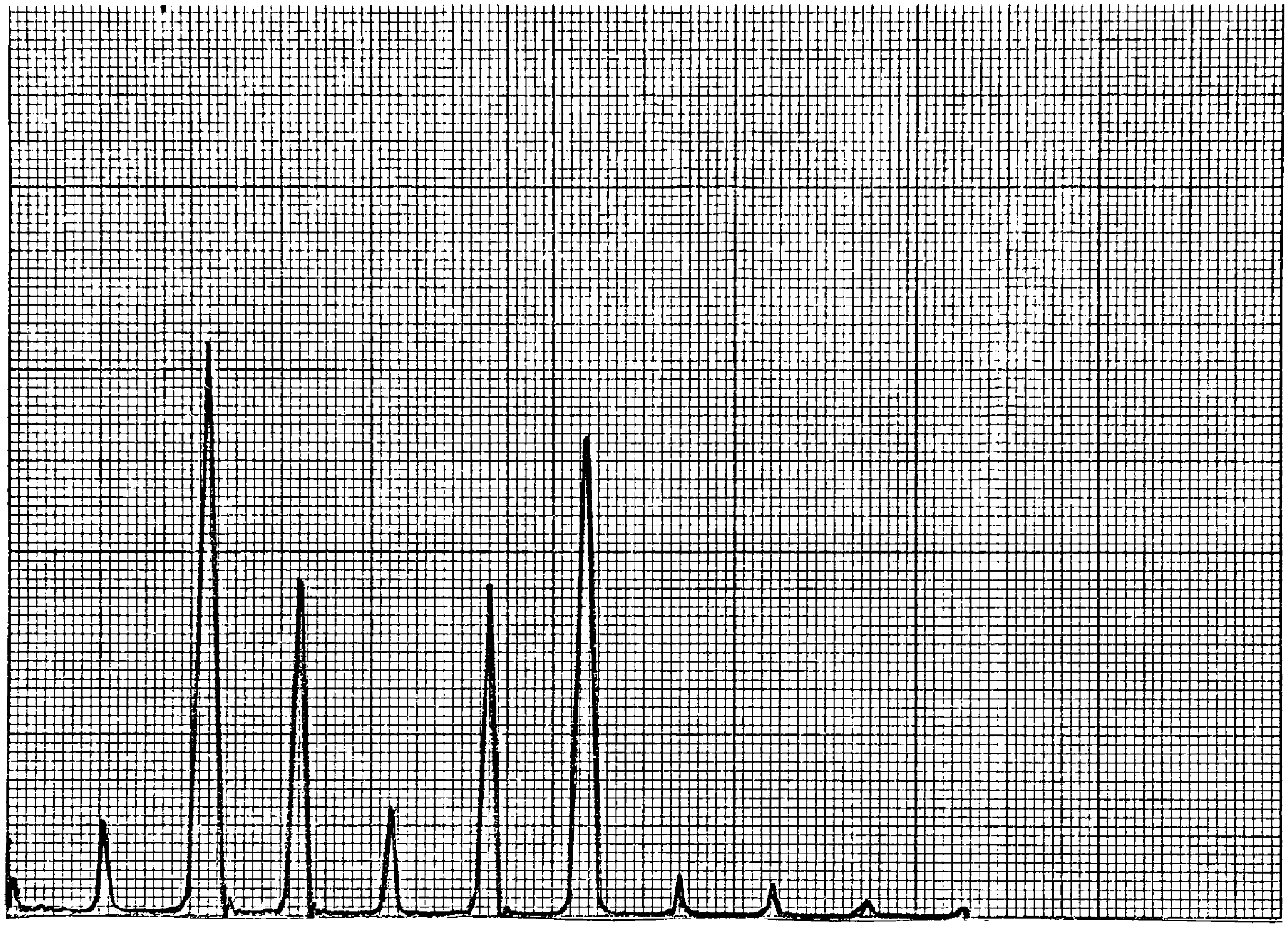


Spectrum Analysis Graph: Group I, Subject Number 1, Pitch e^b.

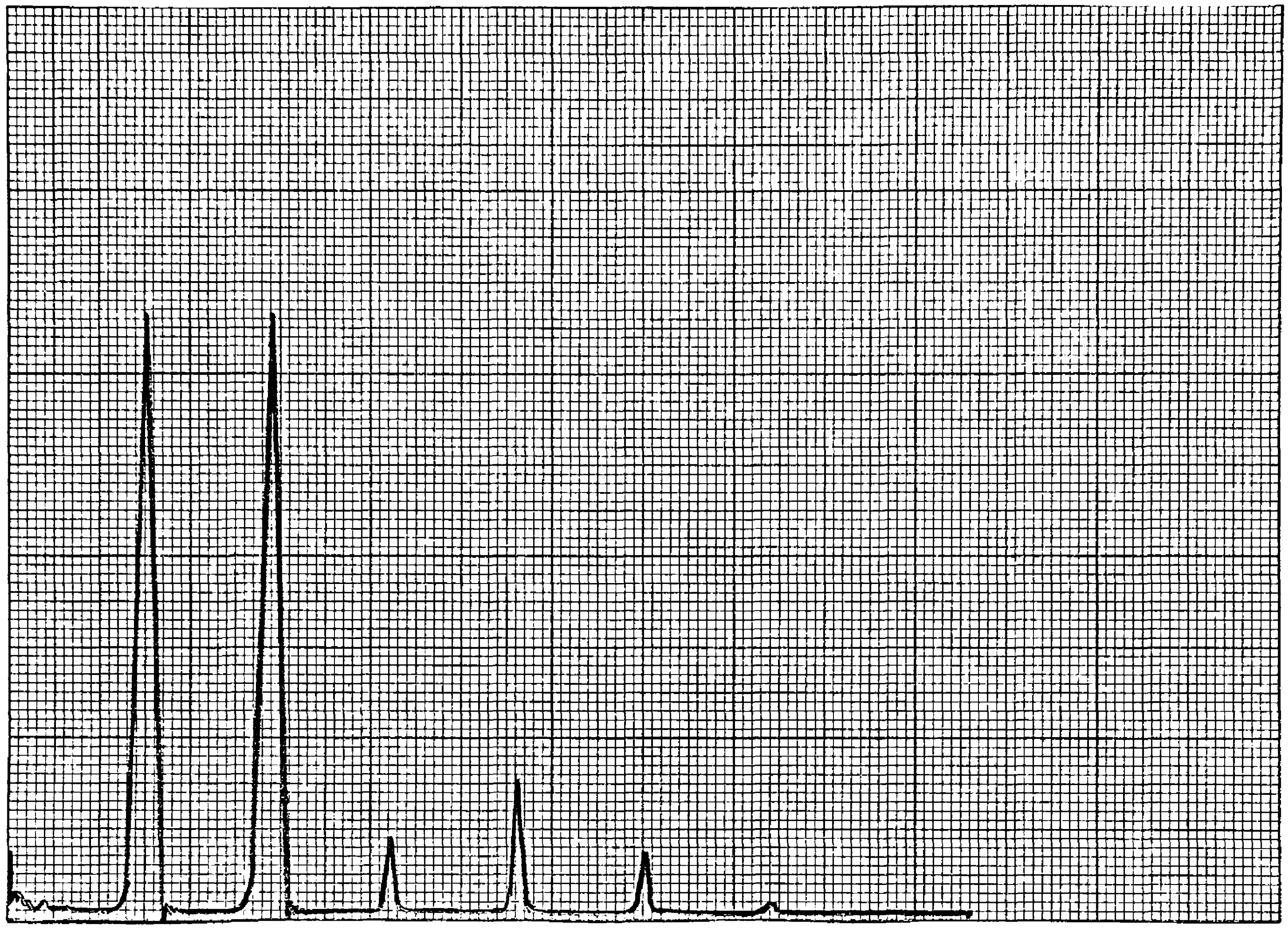
Spectrum Analysis Graph: Group I, Subject Number 2, Pitch d.



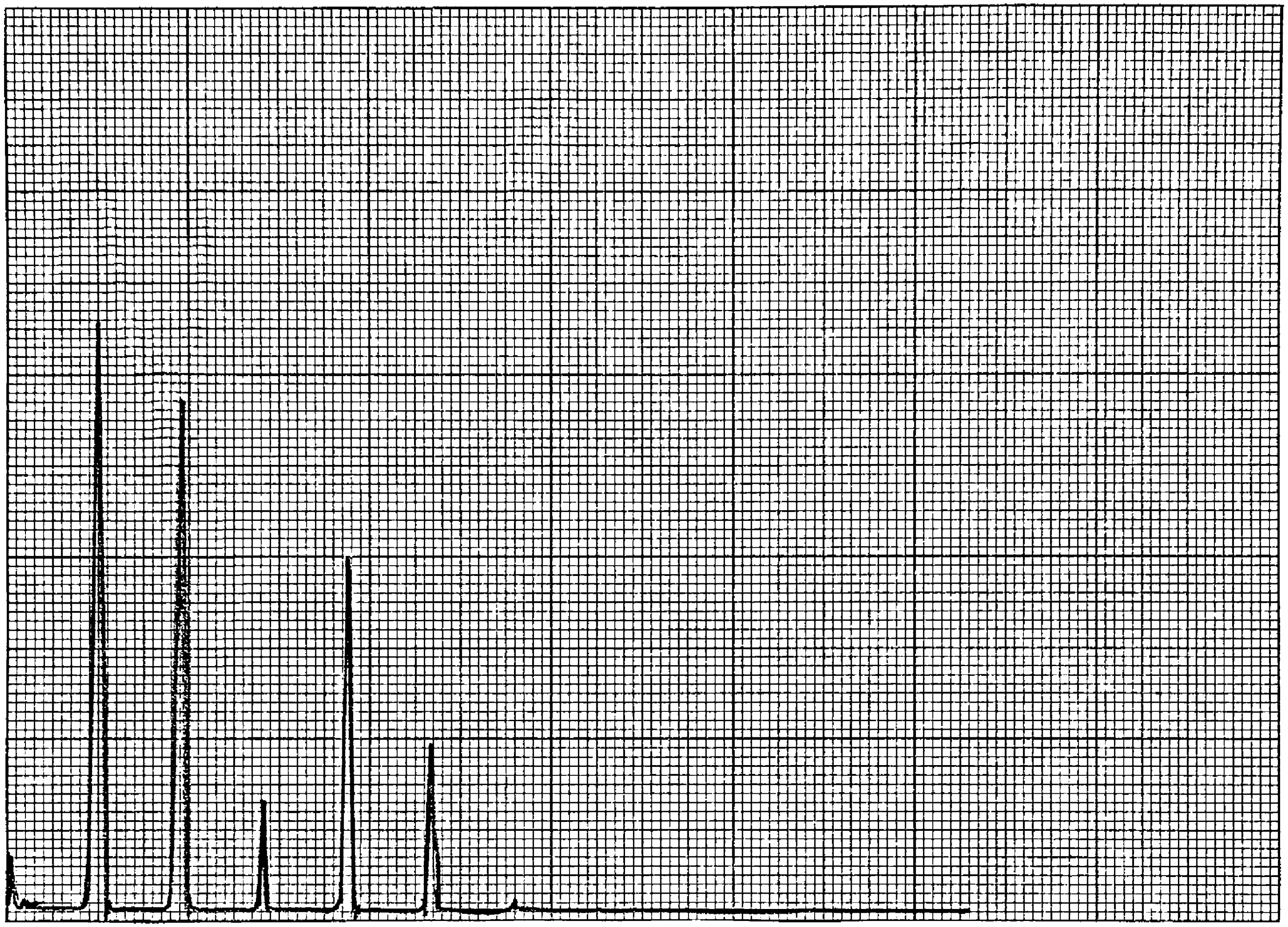
Spectrum Analysis Graph: Group I, Subject Number 2, Pitch g.



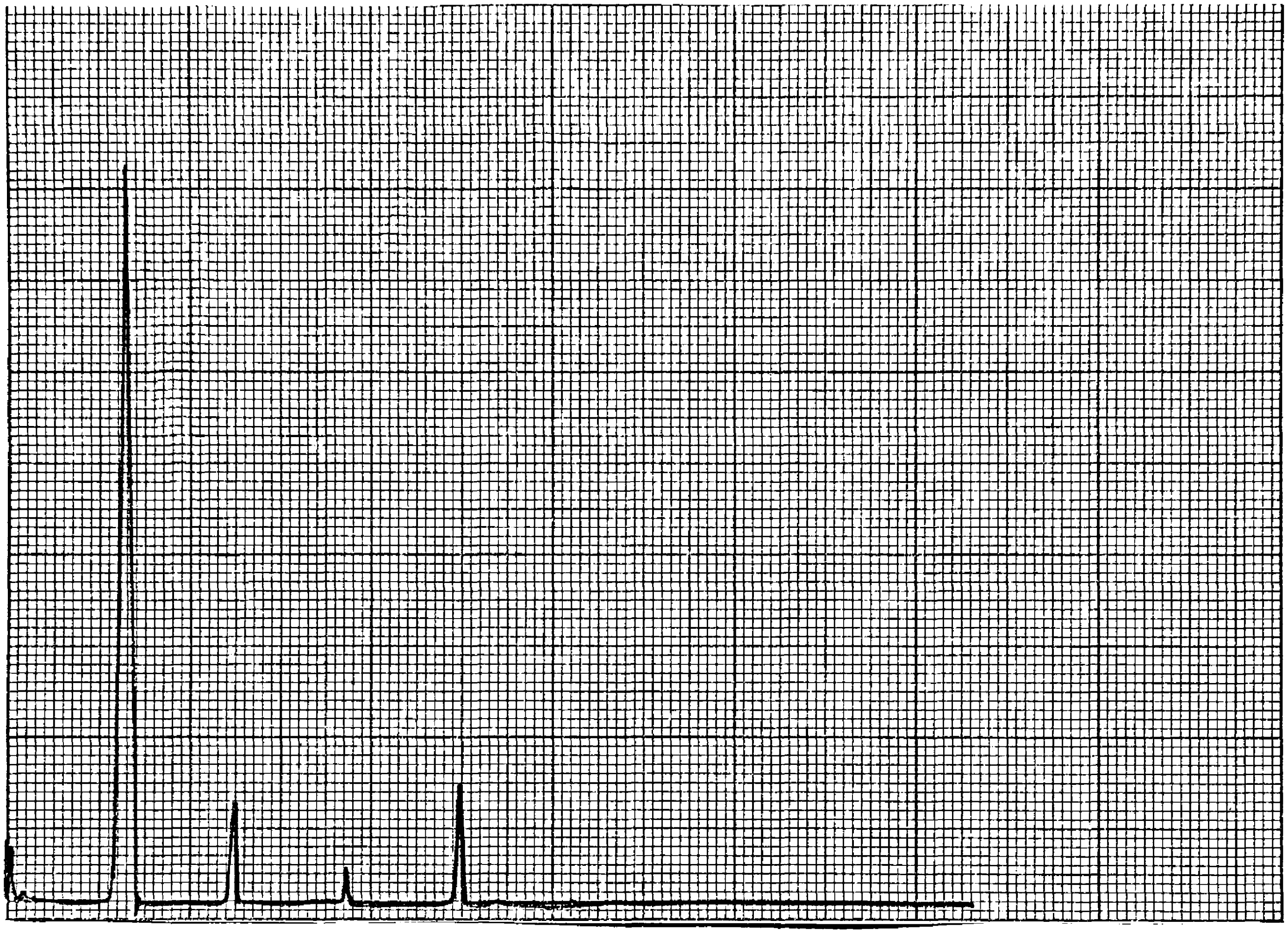
Spectrum Analysis Graph: Group I, Subject Number 2, Pitch c.



Spectrum Analysis Graph: Group I, Subject Number 2, Pitch f.



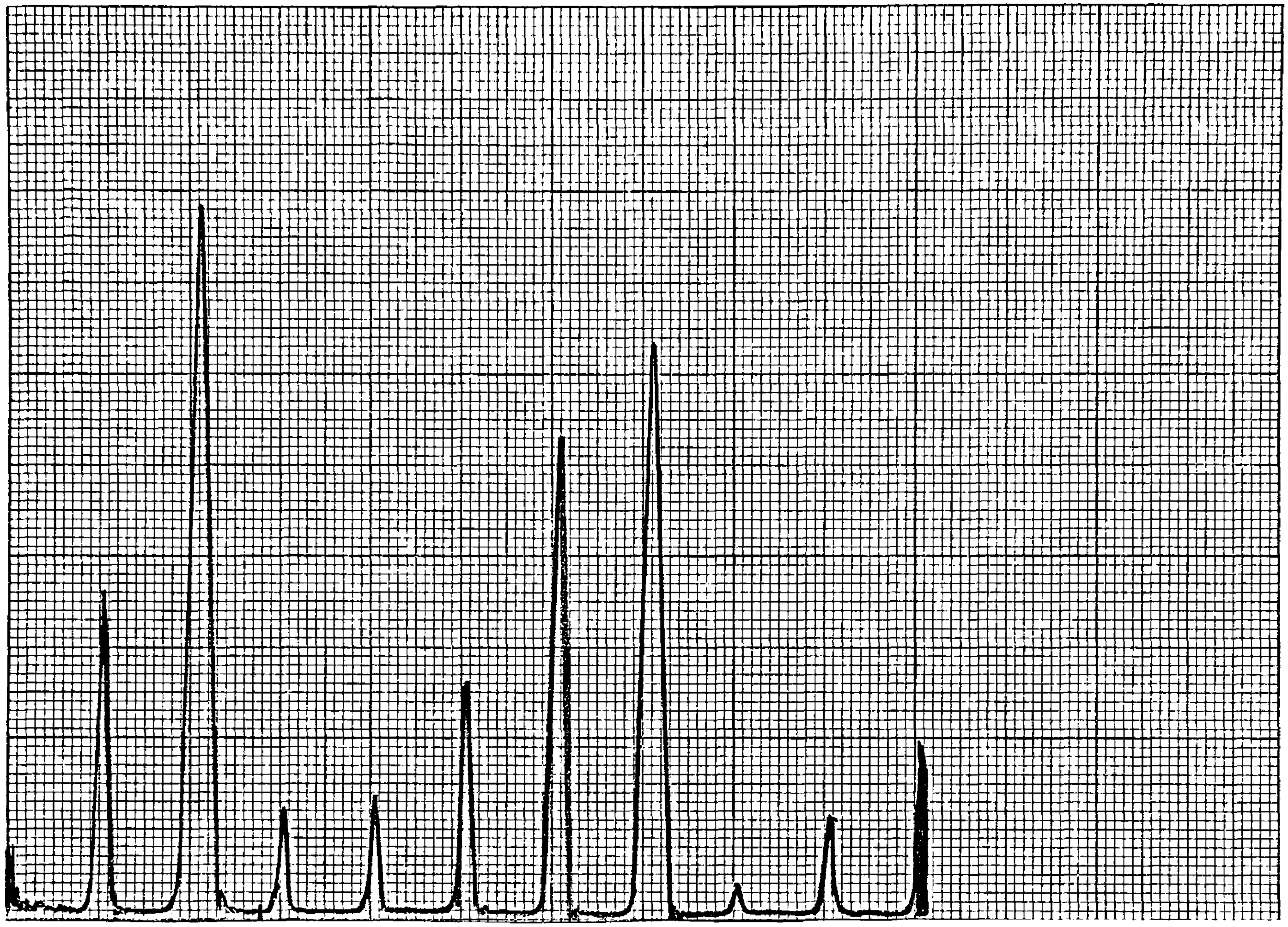
Spectrum Analysis Graph: Group I, Subject Number 2, Pitch b^b.



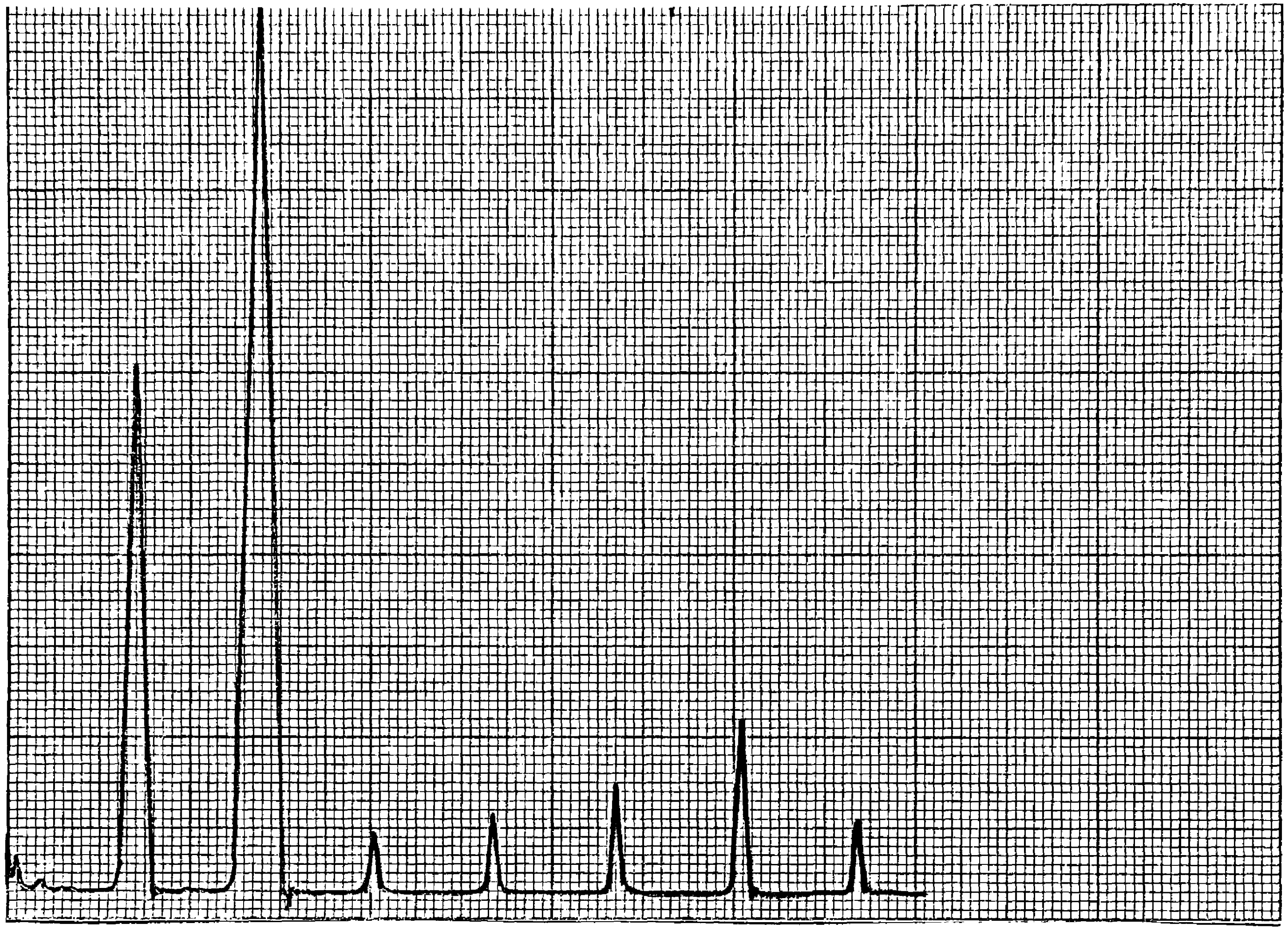
Spectrum Analysis Graph: Group I, Subject Number 2, Pitch e^{b}.

Spectrum Analysis Graph: Group I, Subject Number 3, Pitch d.

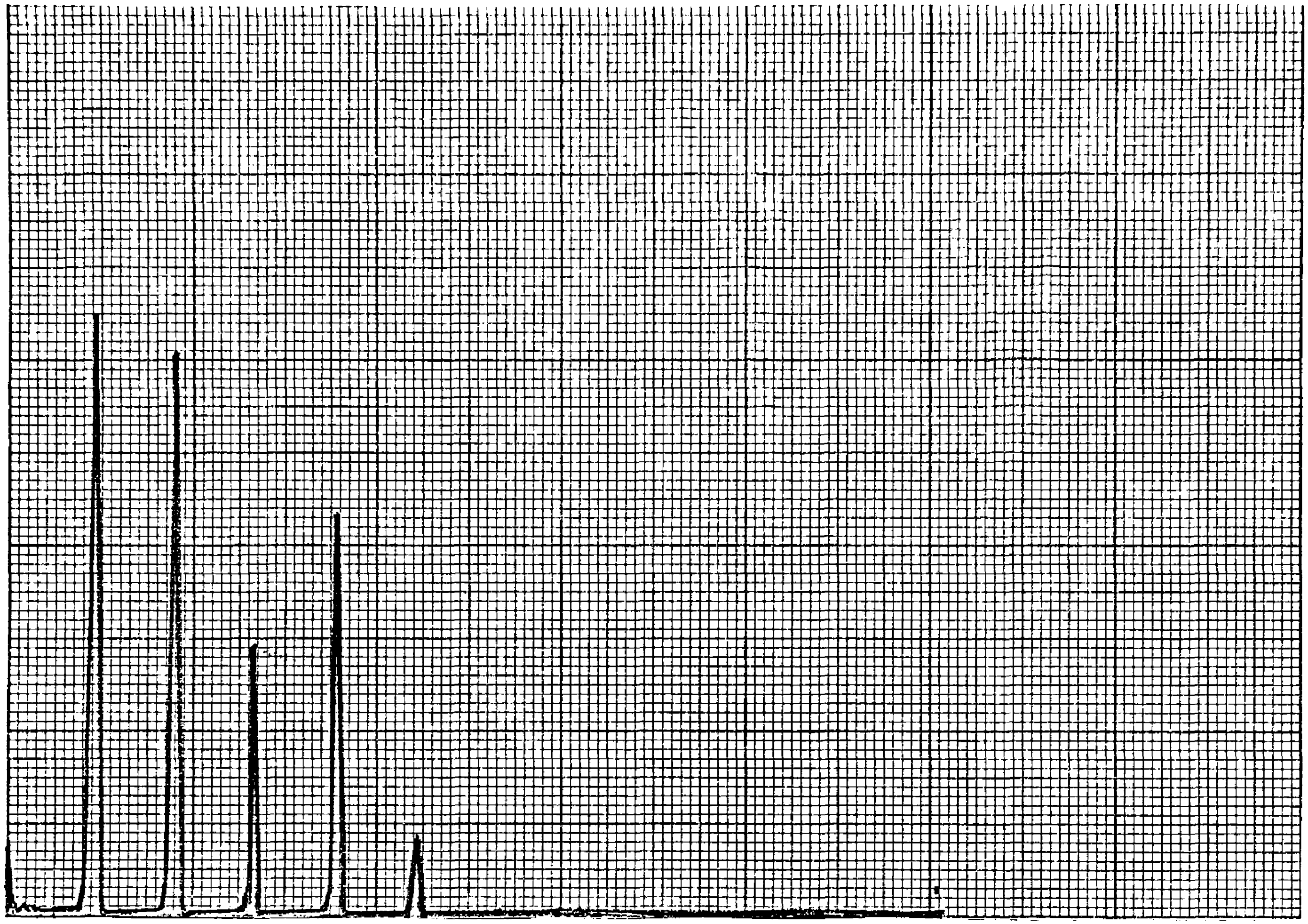
Spectrum Analysis Graph: Group I, Subject Number 3, Pitch g.



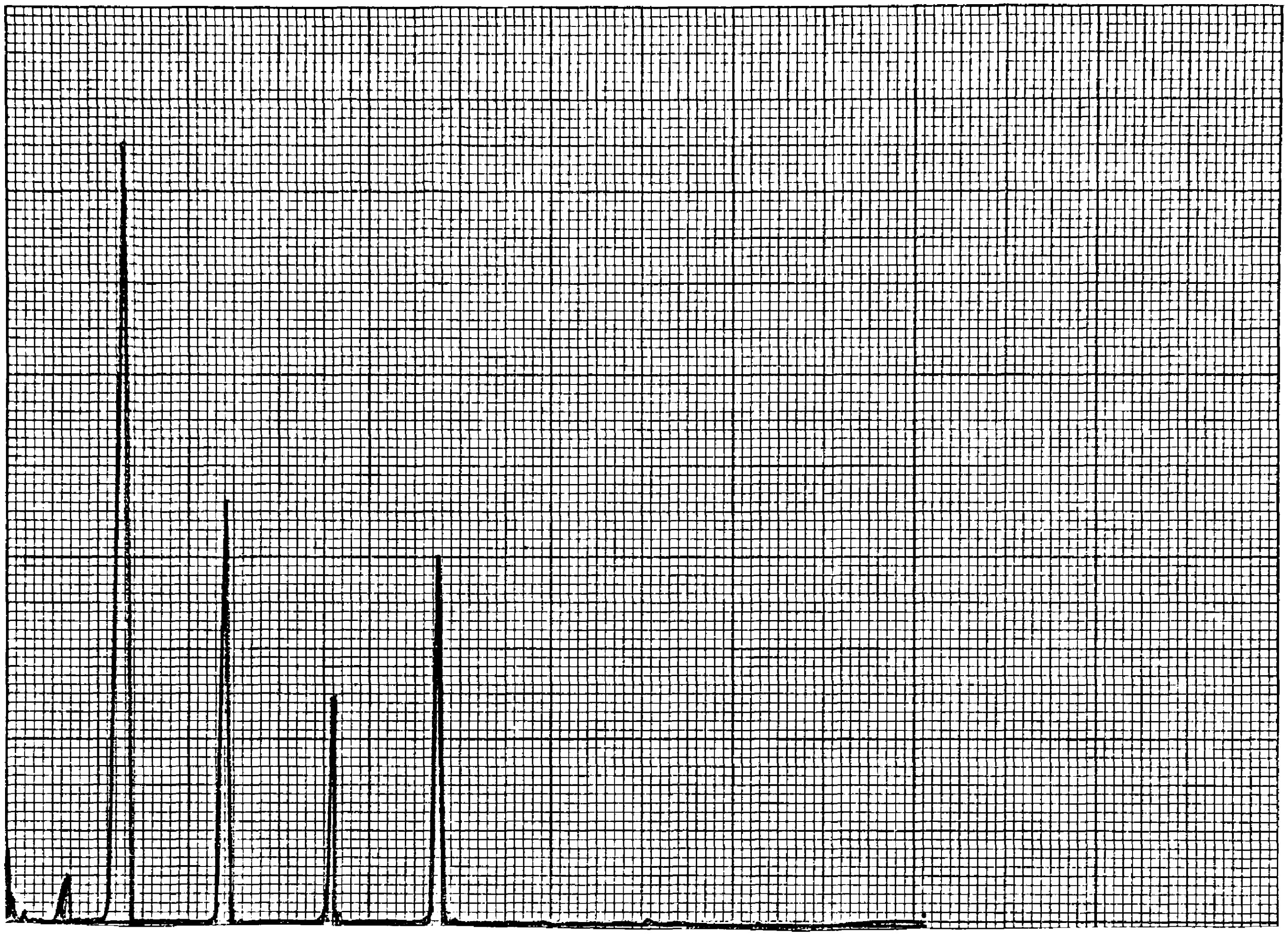
Spectrum Analysis Graph: Group I, Subject Number 3, Pitch c.



Spectrum Analysis Graph: Group I, Subject Number 3, Pitch f.



Spectrum Analysis Graph: Group I, Subject Number 3, Pitch b^b.



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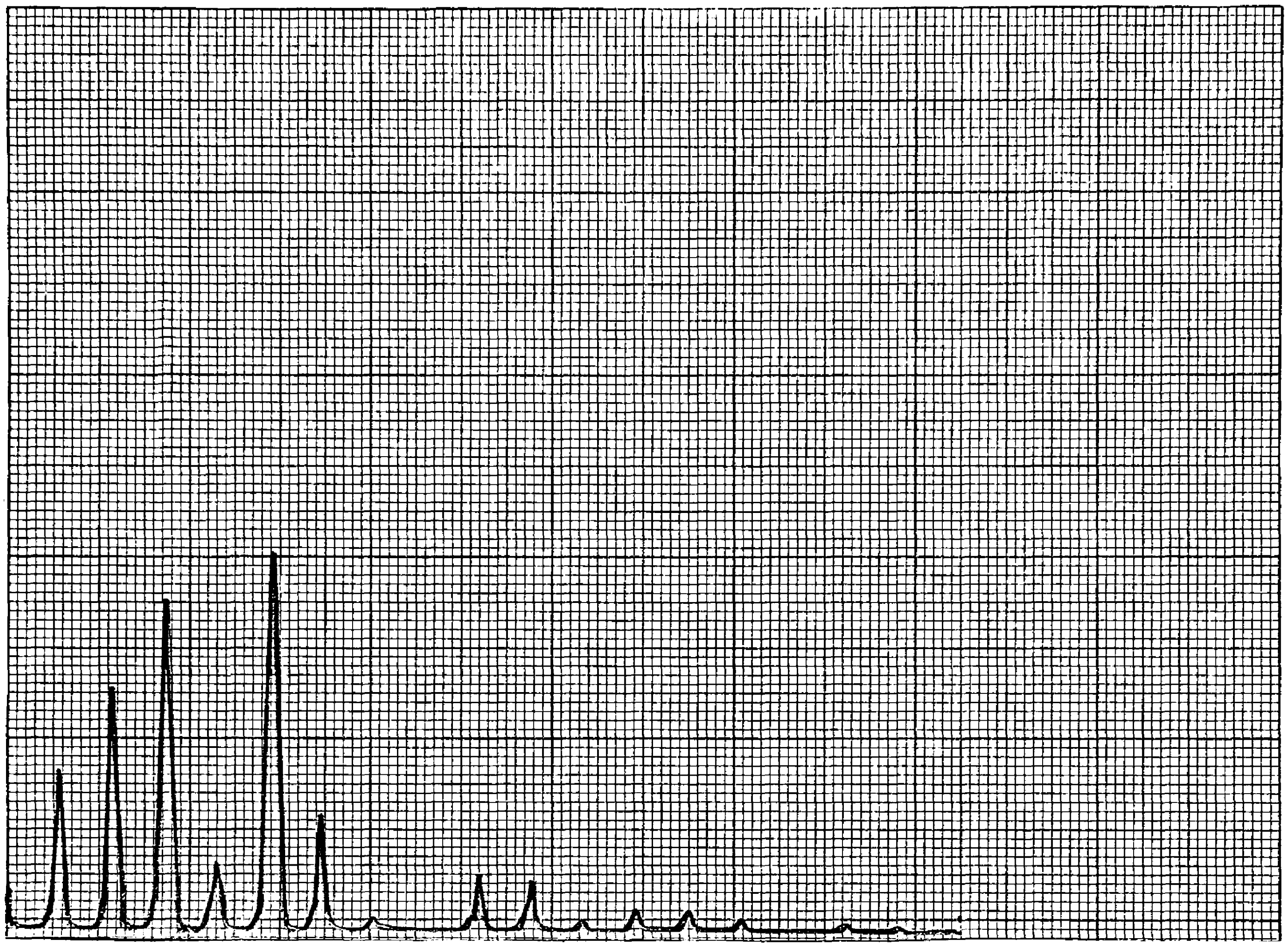
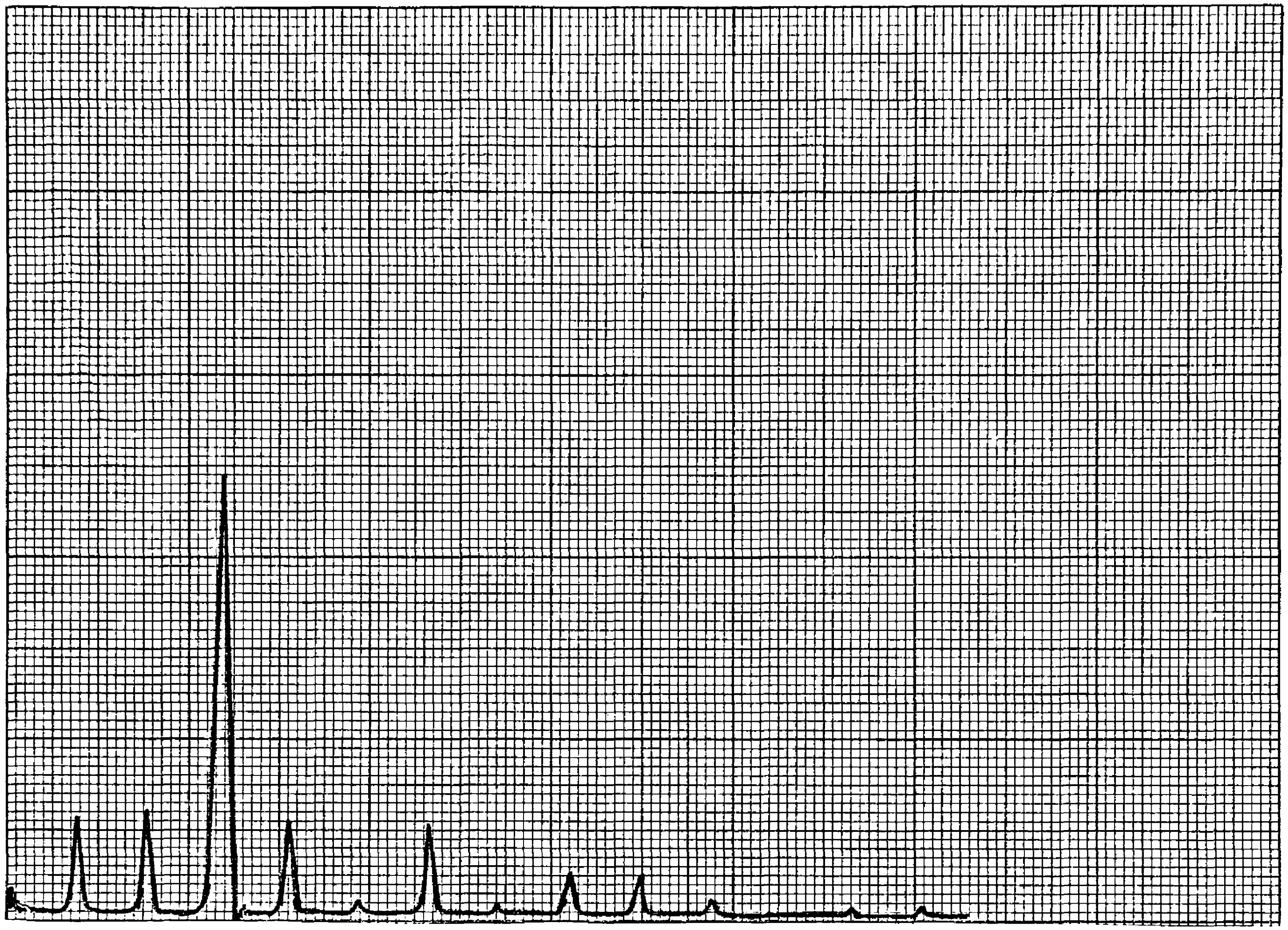
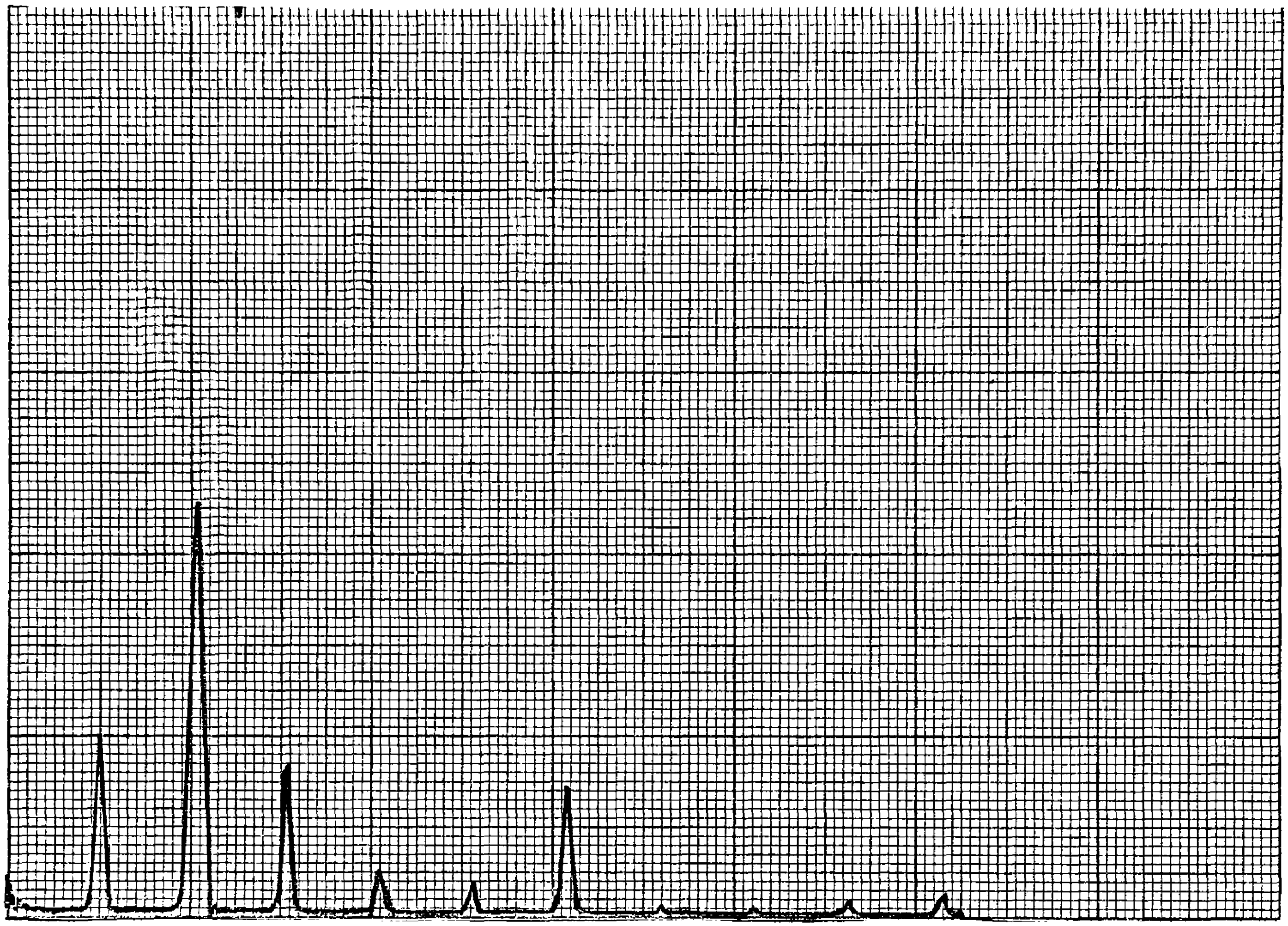


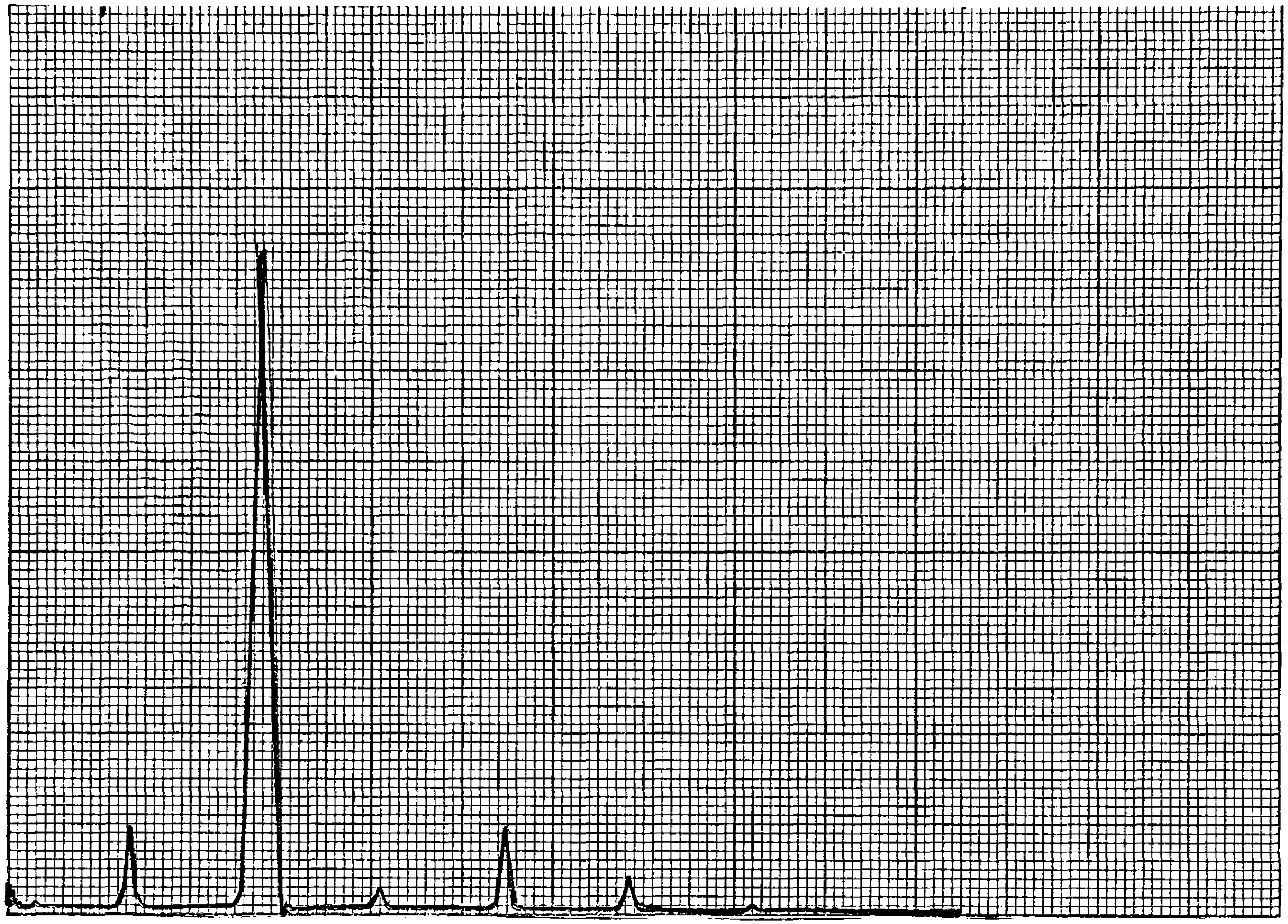
Spectrum Analysis Graph: Group I, Subject Number 13, Pitch d.



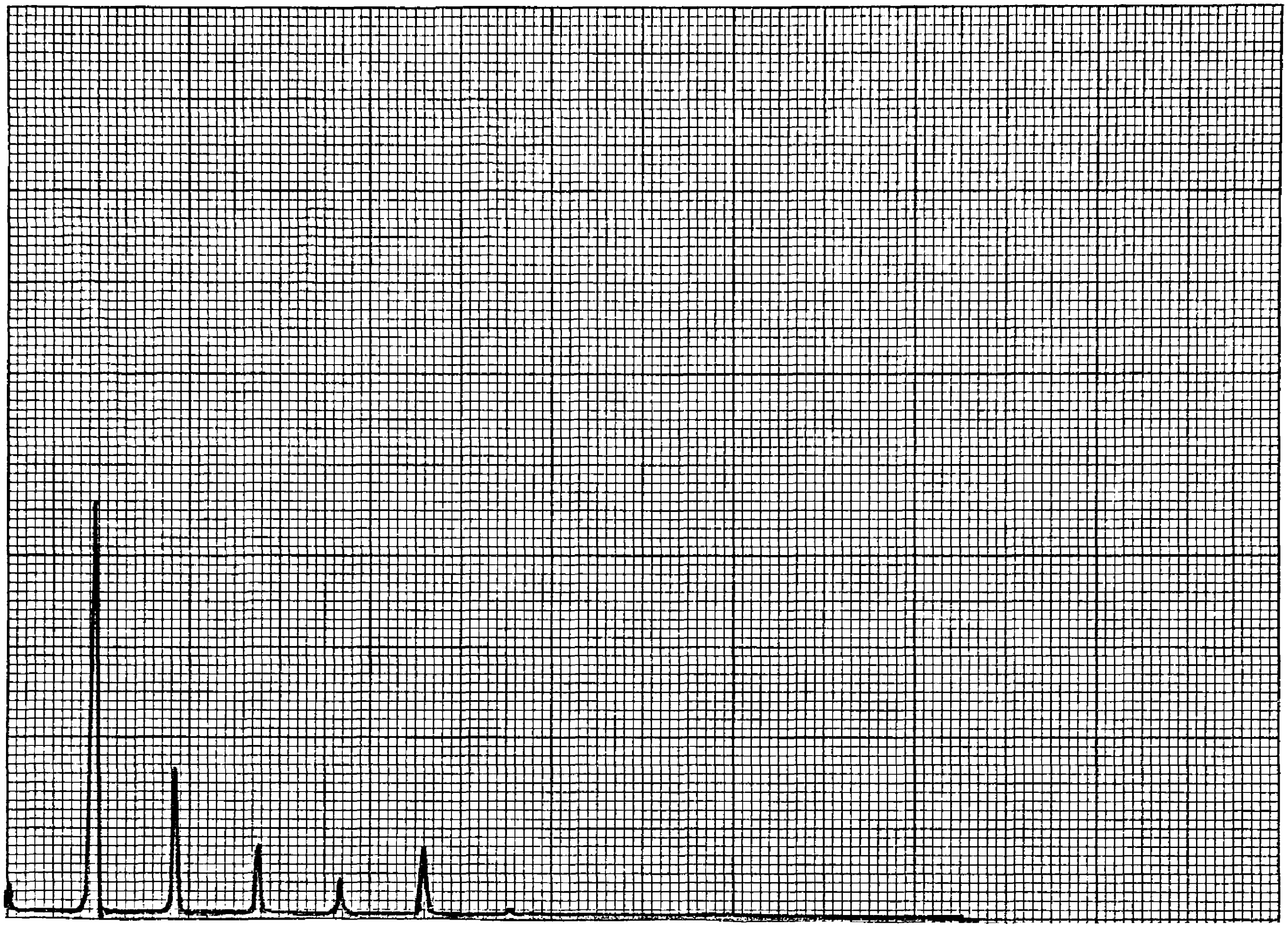
Spectrum Analysis Graph: Group I, Subject Number 13, Pitch g.



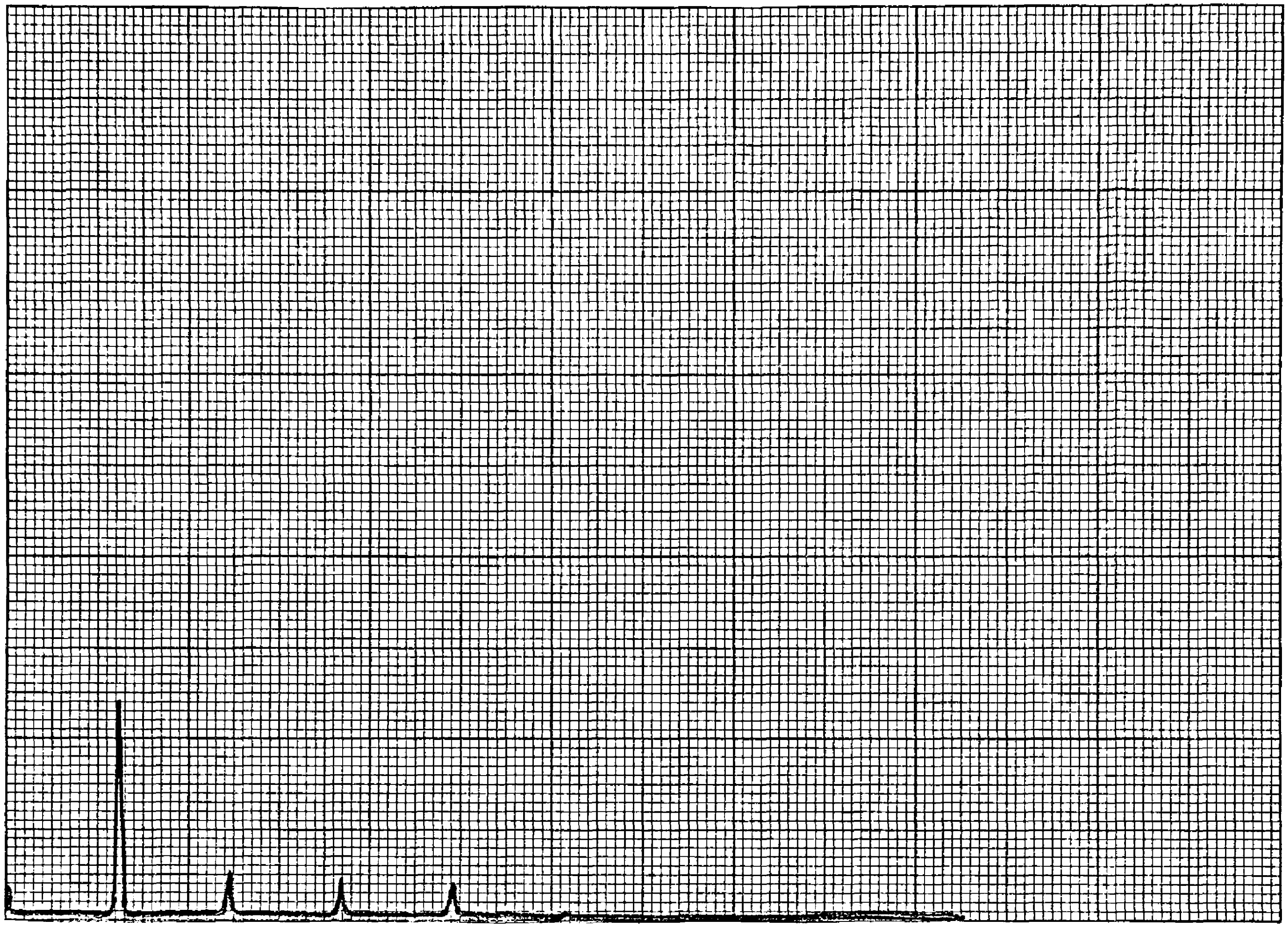
Spectrum Analysis Graph: Group I, Subject Number 13, Pitch c.



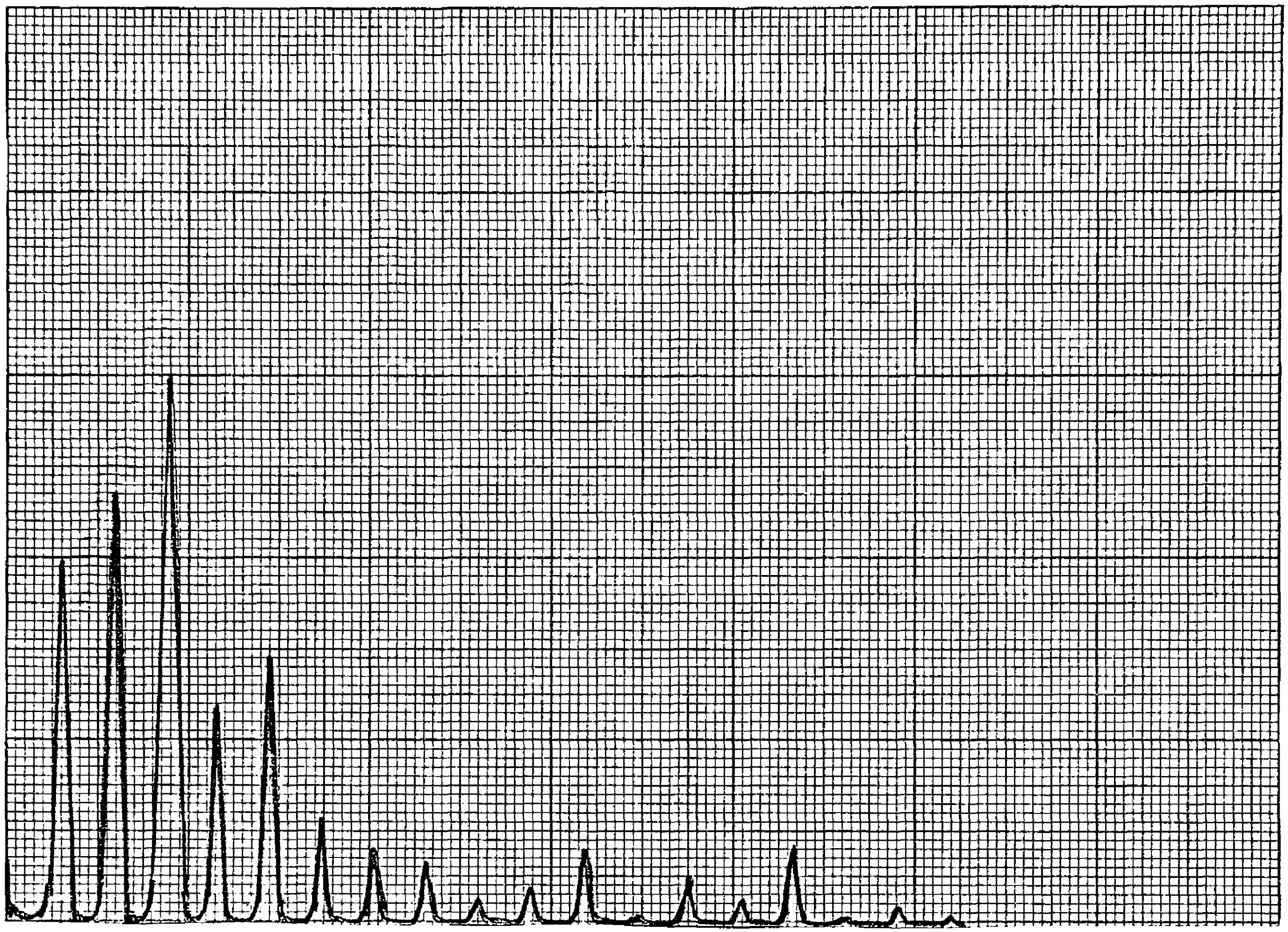
Spectrum Analysis Graph: Group I, Subject Number 13, Pitch f.



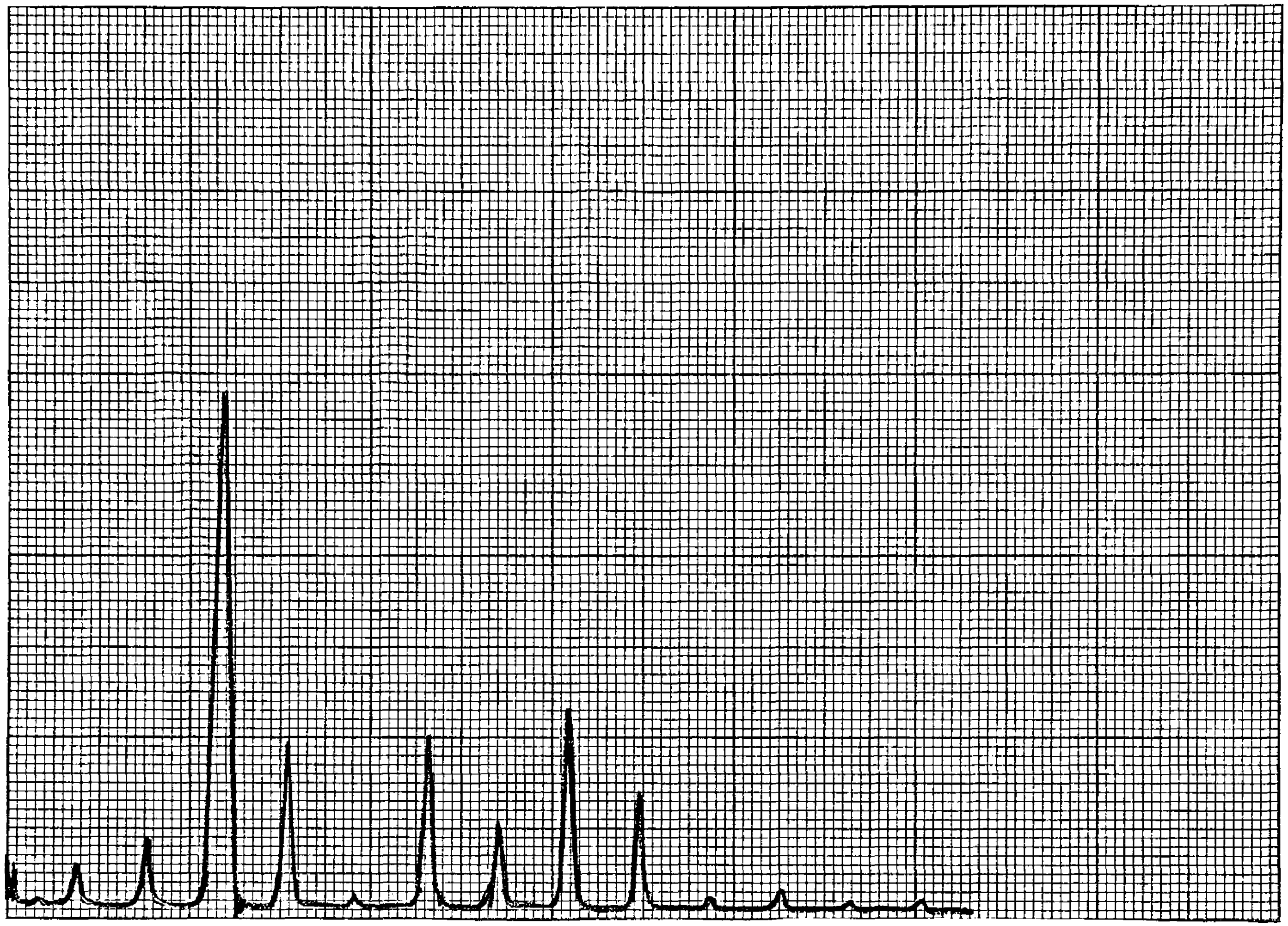
Spectrum Analysis Graph: Group I, Subject Number 13, Pitch b^b.



Spectrum Analysis Graph: Group I, Subject Number 13, Pitch e^b.

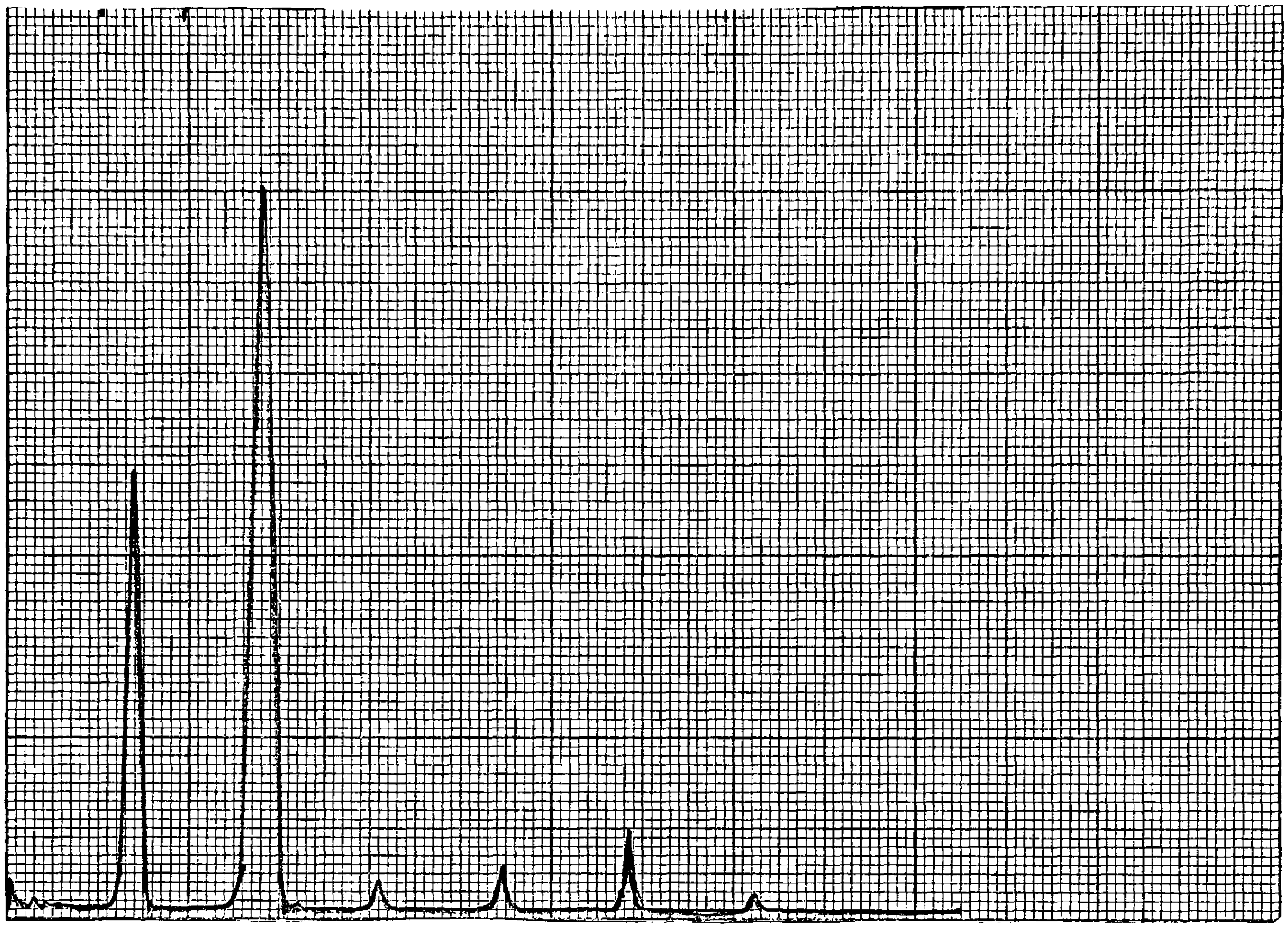


Spectrum Analysis Graph: Group I, Subject Number 14, Pitch d.

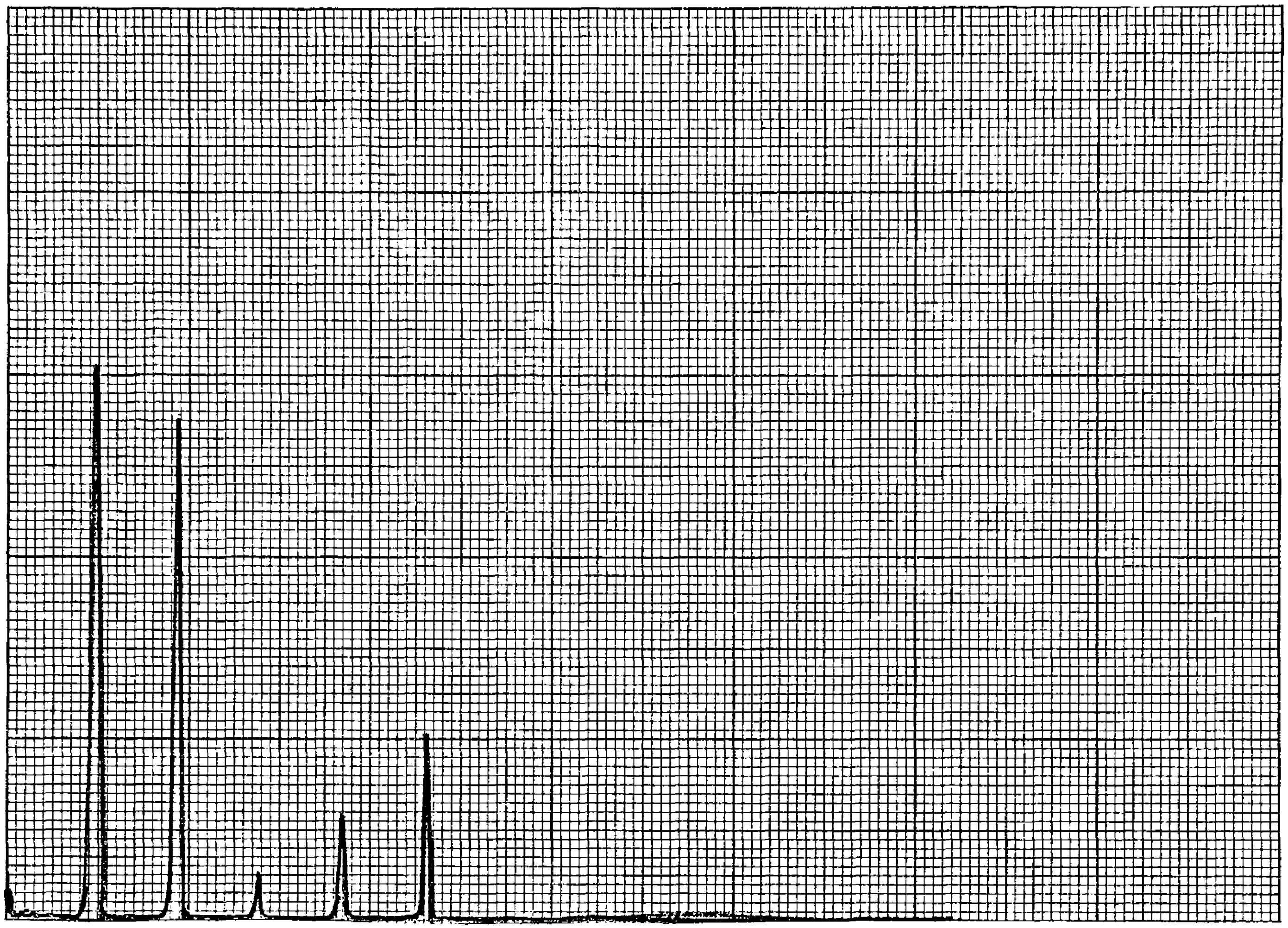


Spectrum Analysis Graph: Group I, Subject Number 14, Pitch g.

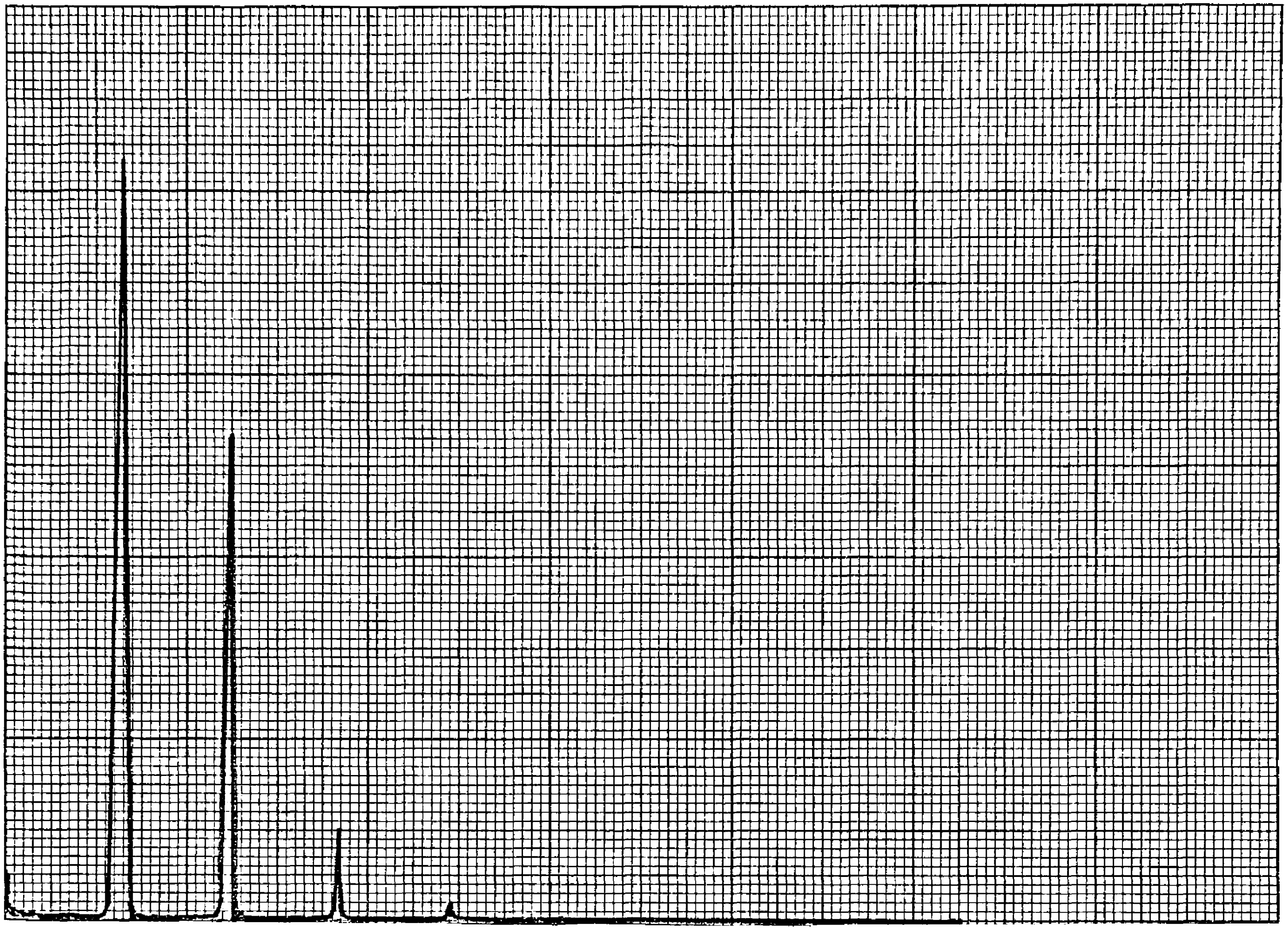
Spectrum Analysis Graph: Group I, Subject Number 14, Pitch c.



Spectrum Analysis Graph: Group I, Subject Number 14, Pitch f.

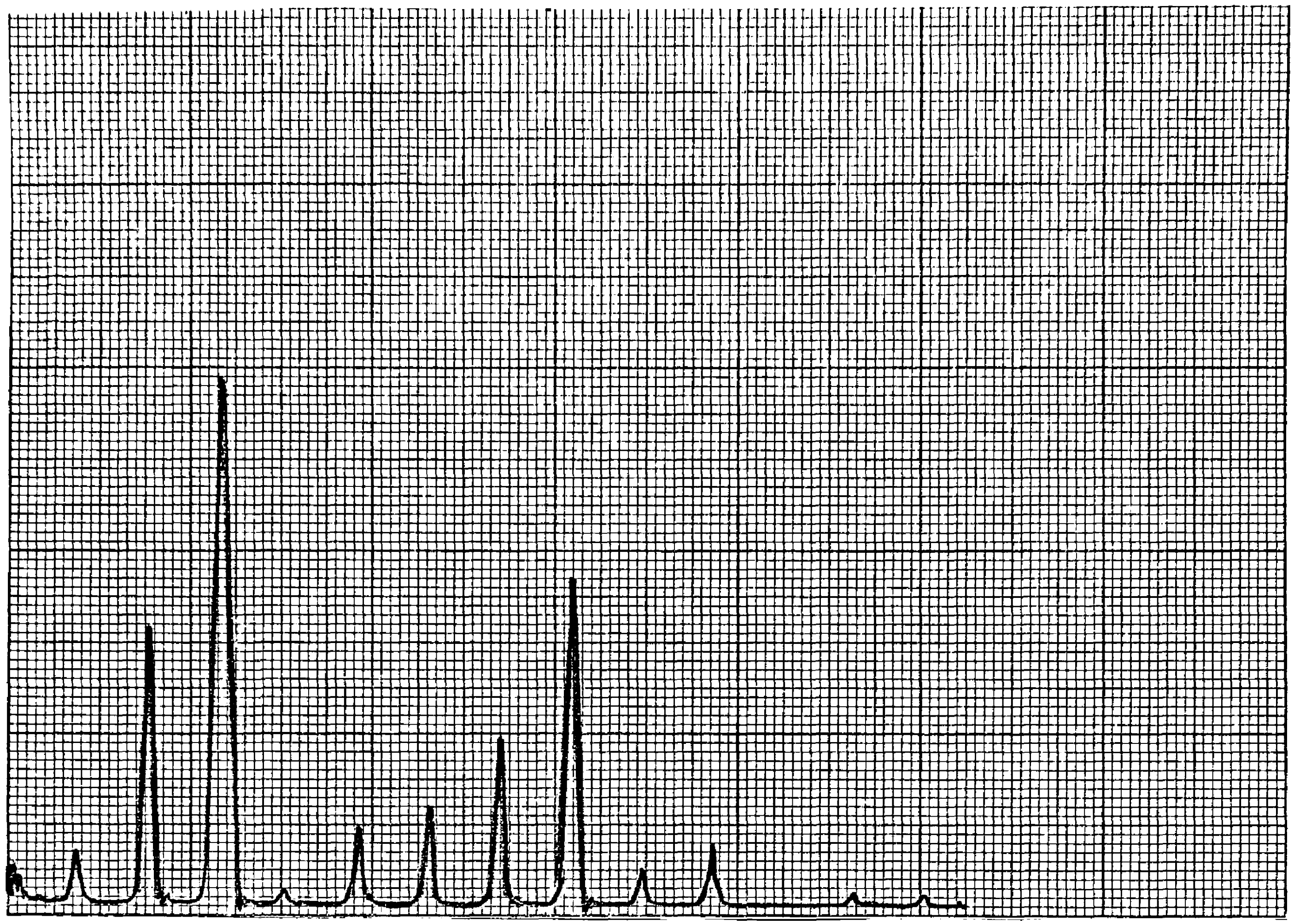


Spectrum Analysis Graph: Group I, Subject Number 14, Pitch b^b.

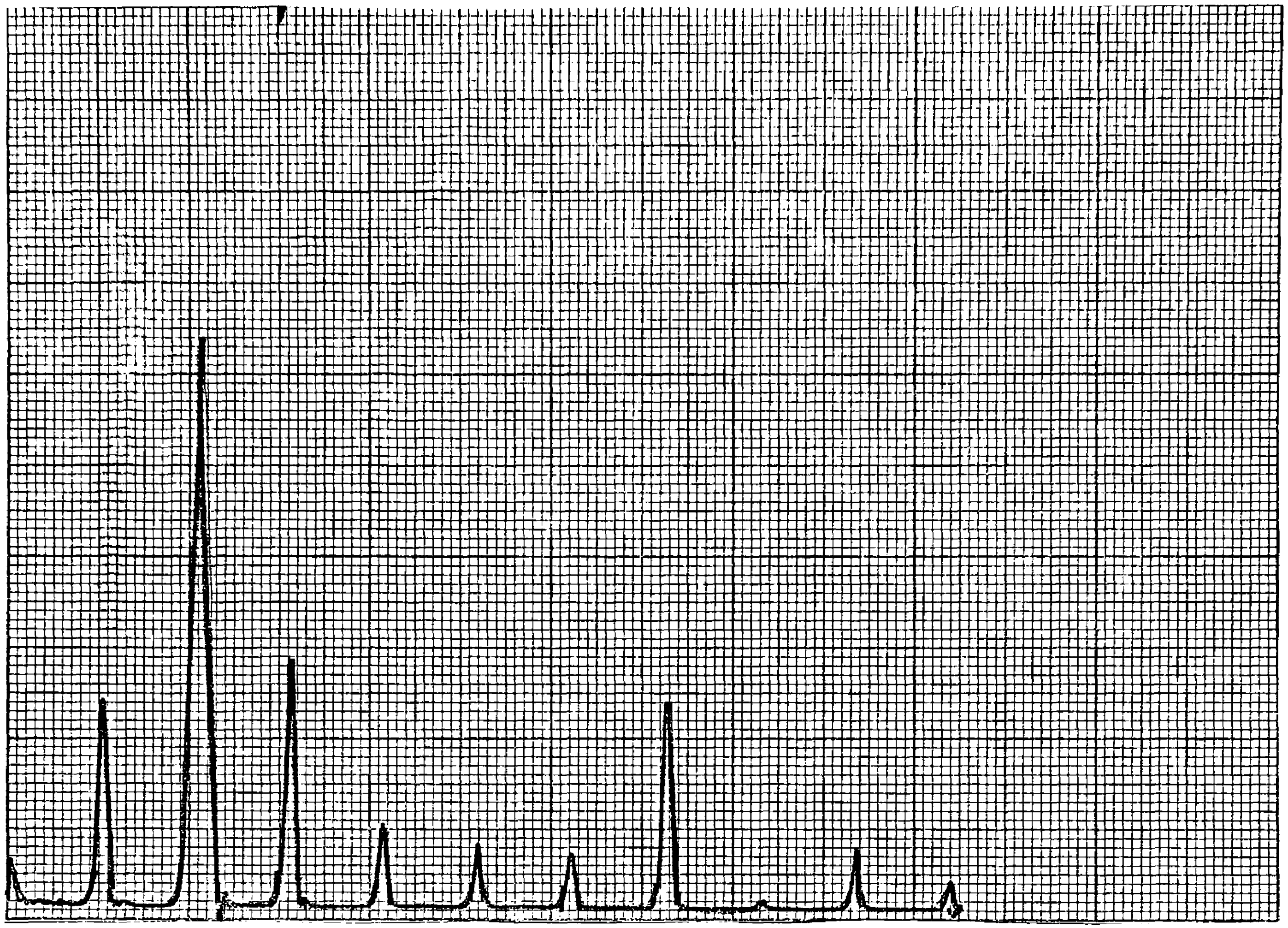


Spectrum Analysis Graph: Group I, Subject Number 14, Pitch e^b.

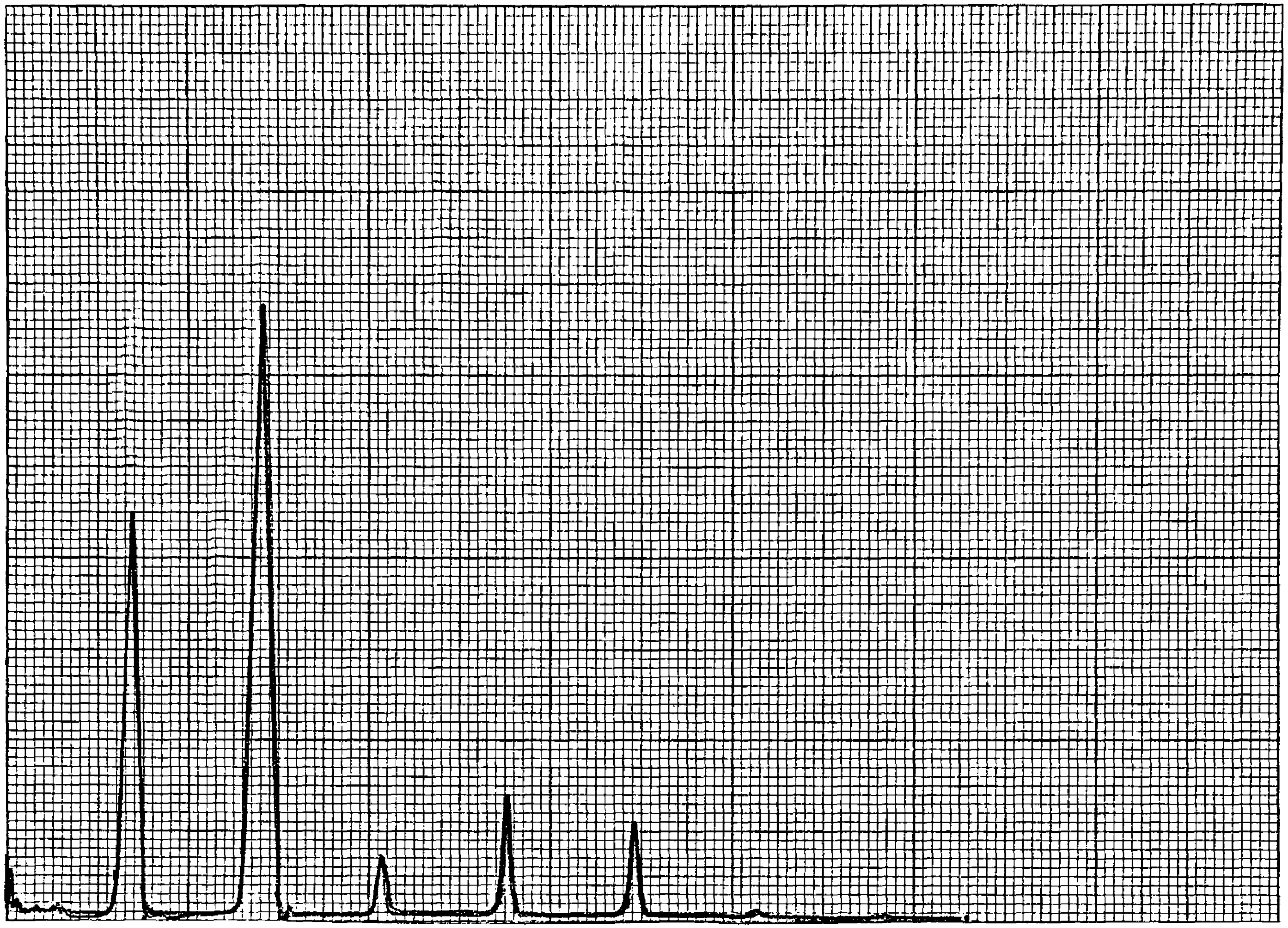
Spectrum Analysis Graph: Group I, Subject Number 15, Pitch d.



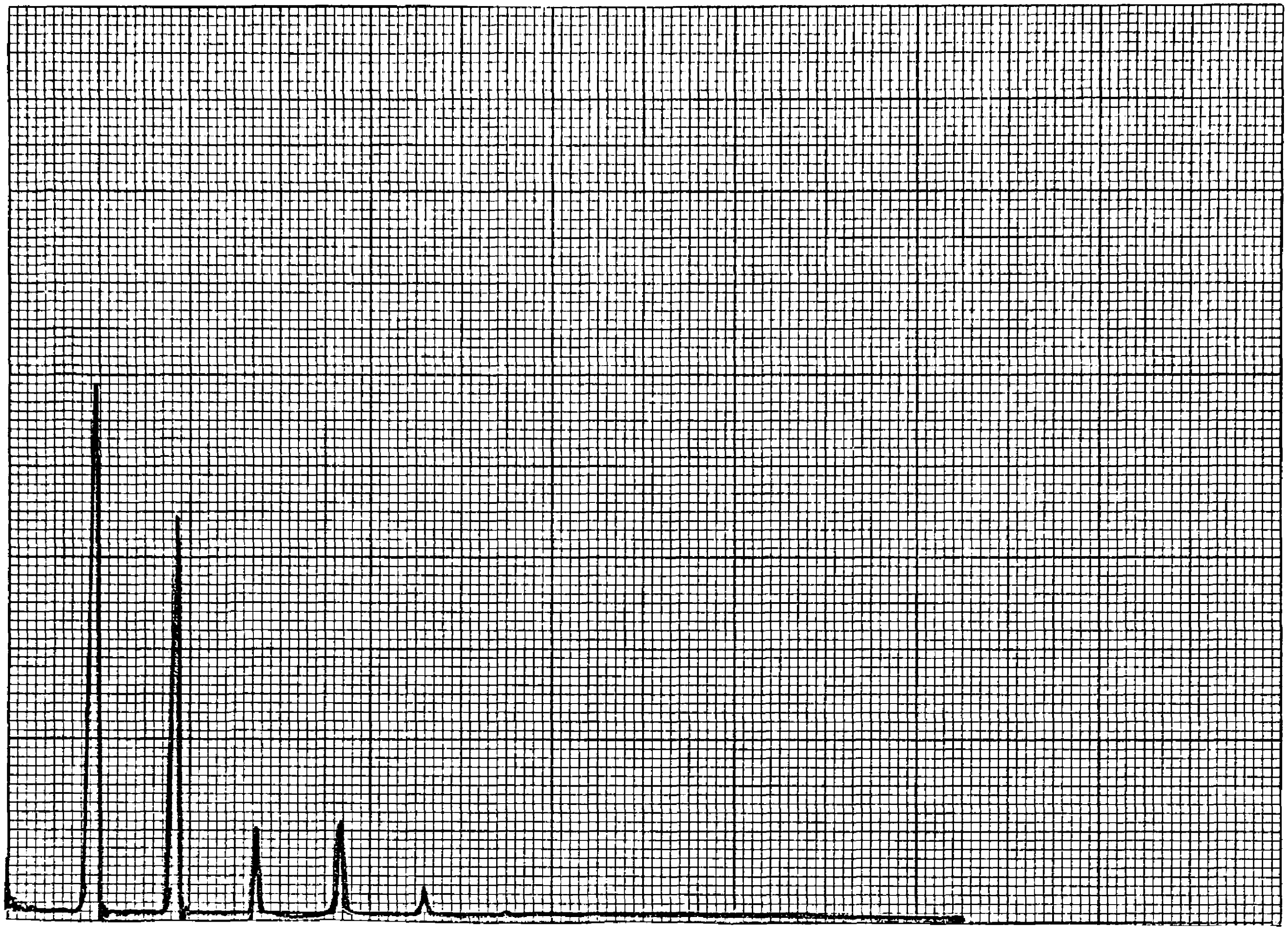
Spectrum Analysis Graph: Group I, Subject Number 15, Pitch g.



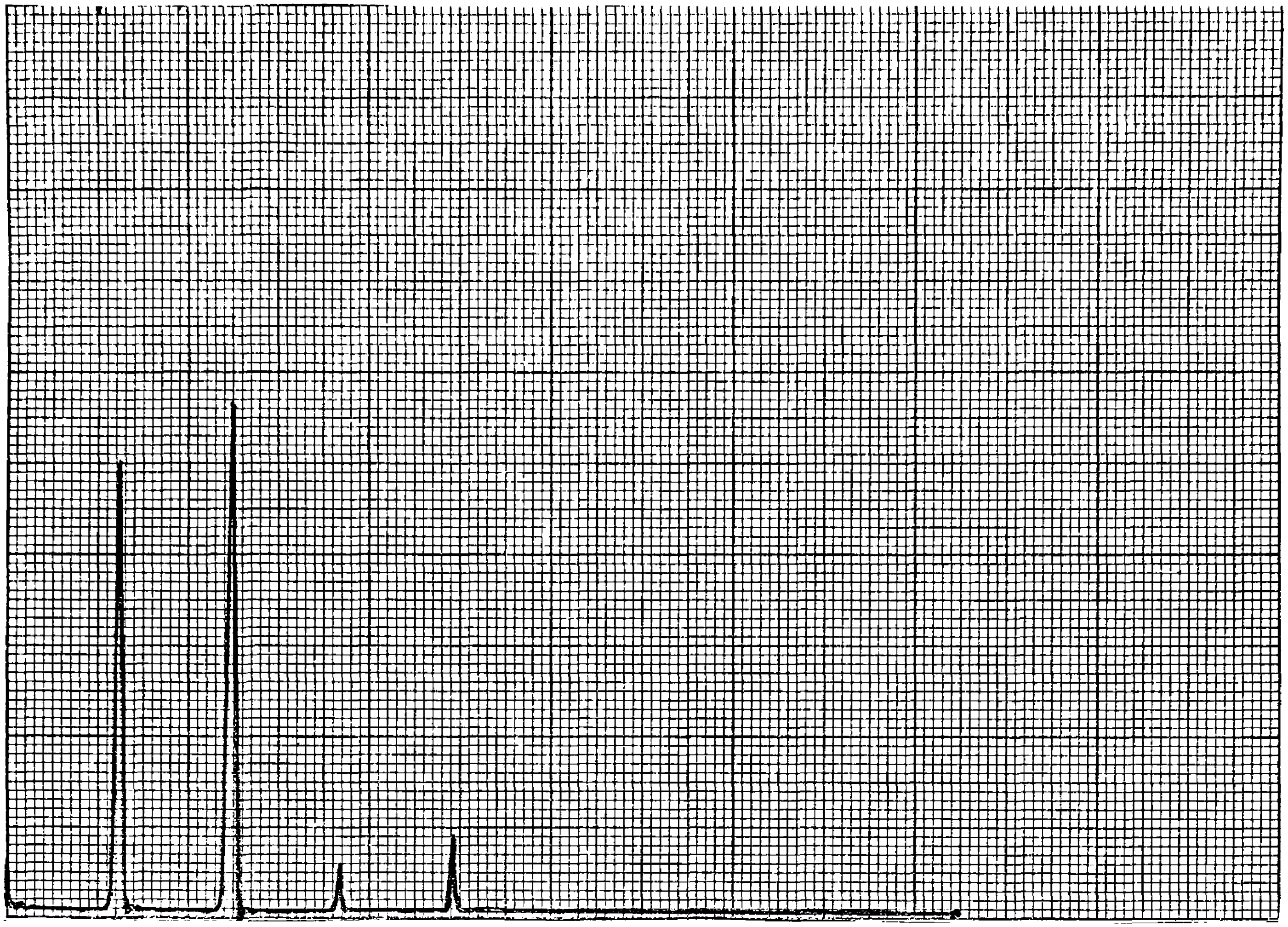
Spectrum Analysis Graph: Group I, Subject Number 15, Pitch c.



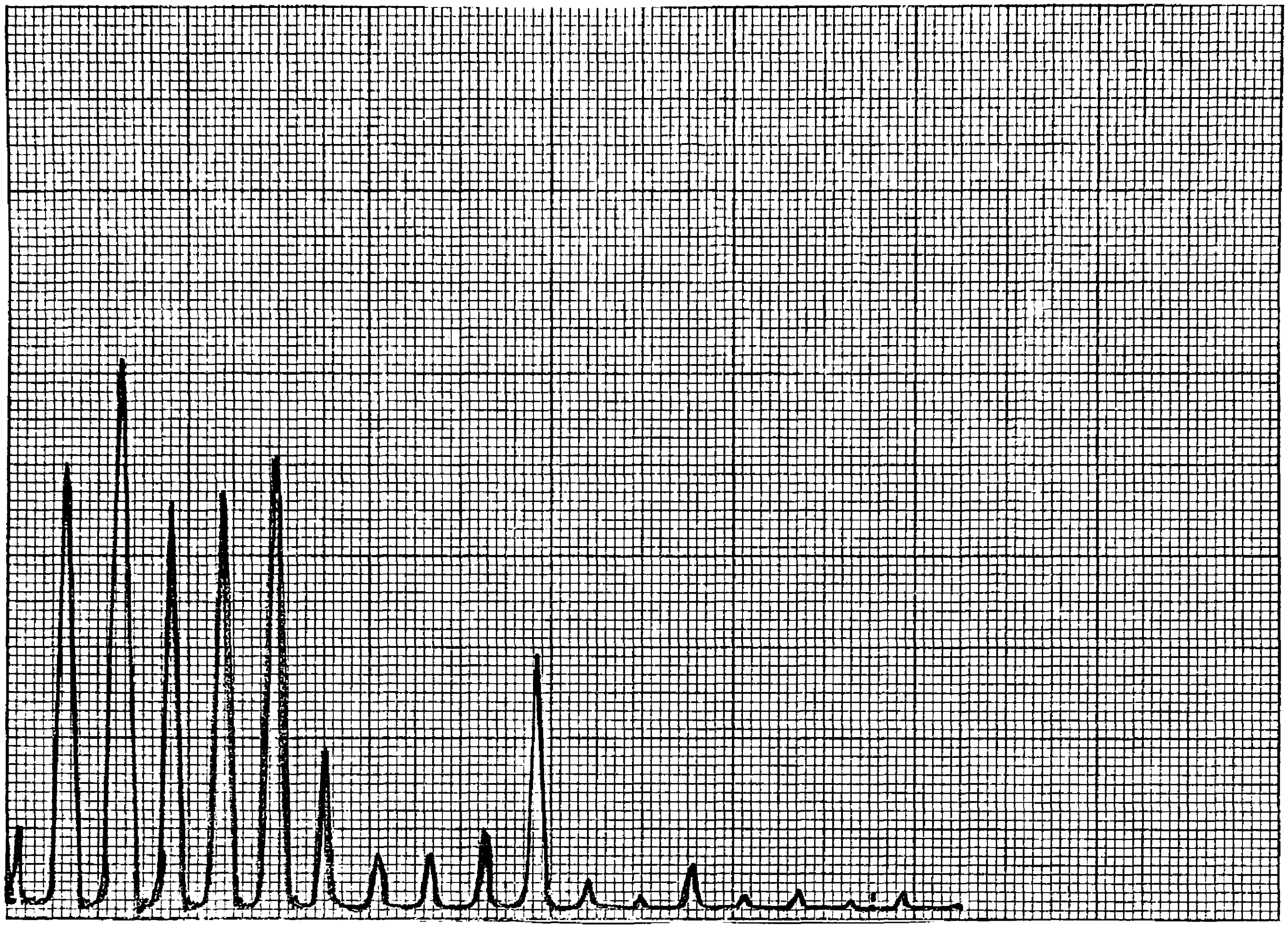
Spectrum Analysis Graph: Group I, Subject Number 15, Pitch f.



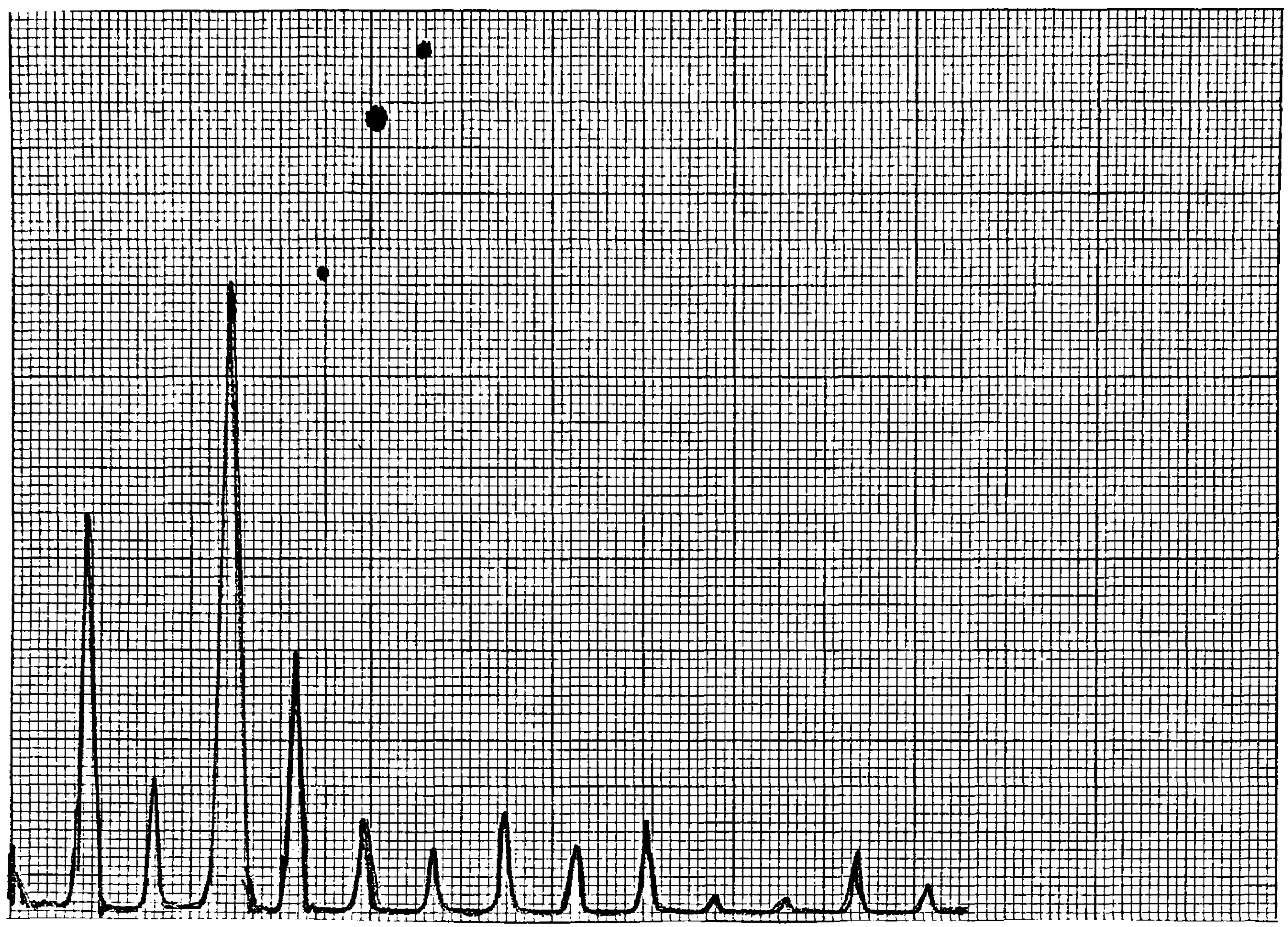
Spectrum Analysis Graph: Group I, Subject Number 15, Pitch b^b.



Spectrum Analysis Graph: Group I, Subject Number 15, Pitch e^b.

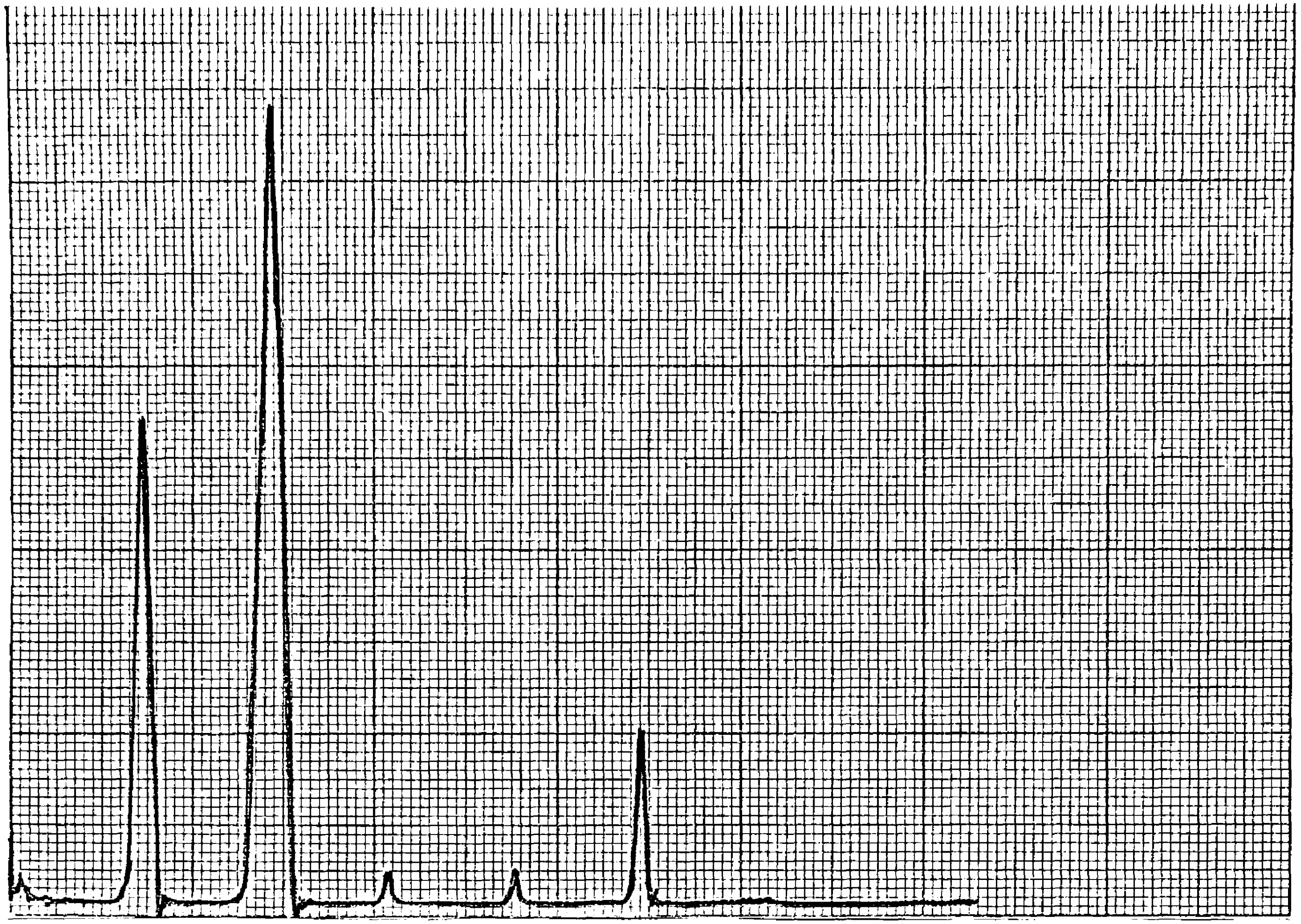


Spectrum Analysis Graph: Group I, Subject Number 25, Pitch d.

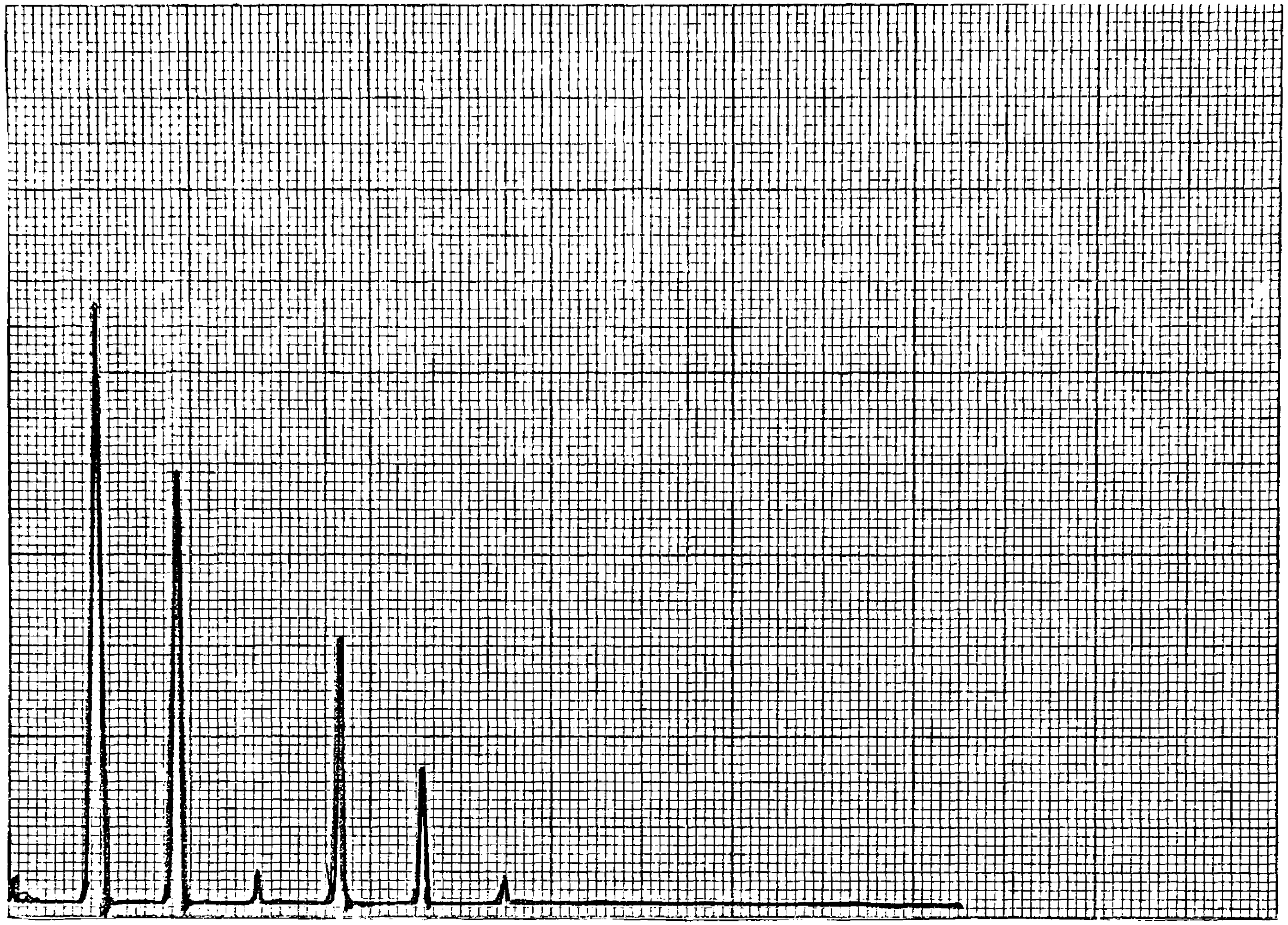


Spectrum Analysis Graph: Group I, Subject Number 25, Pitch g.

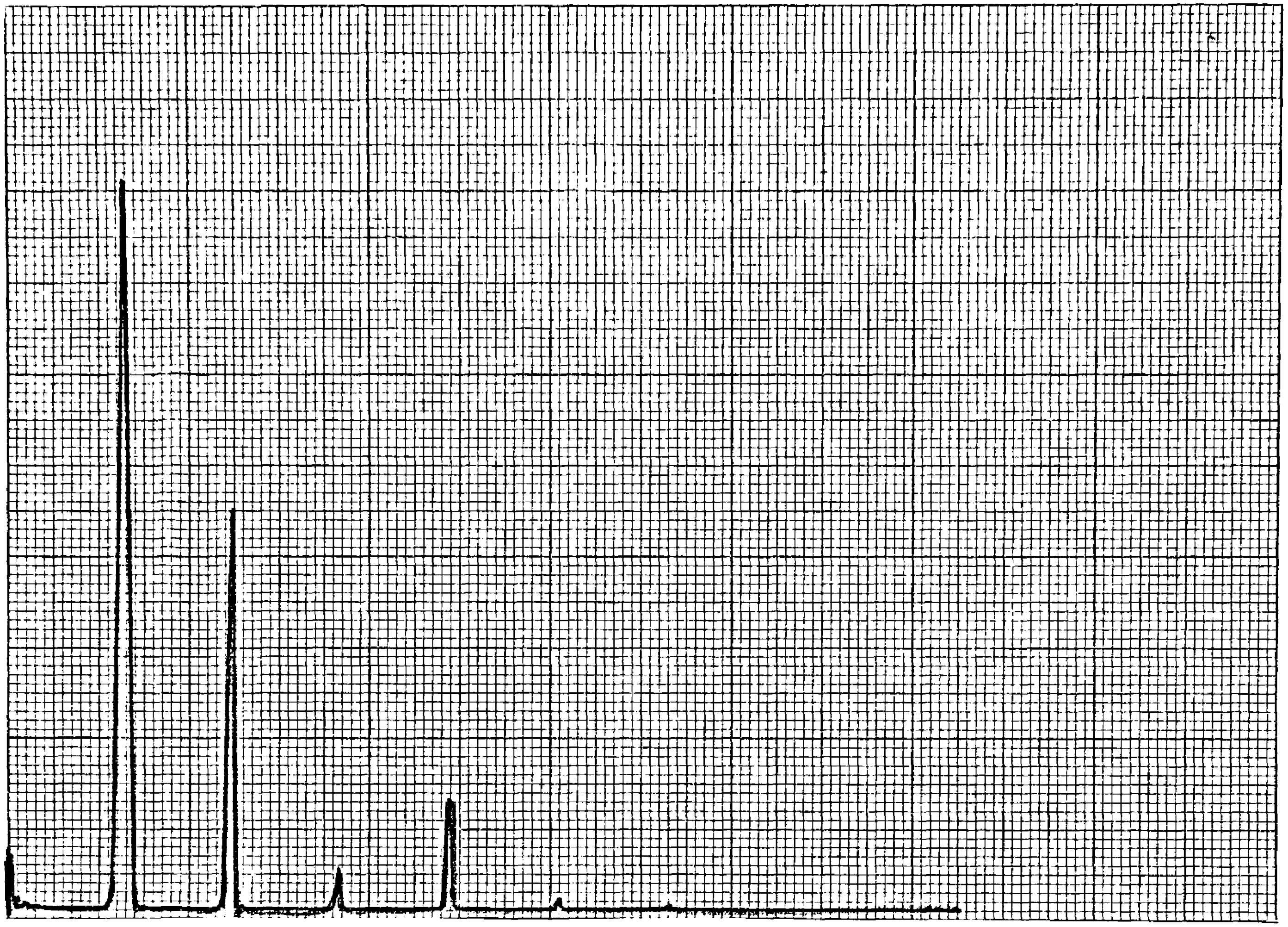
Spectrum Analysis Graph: Group I, Subject Number 25, Pitch c.



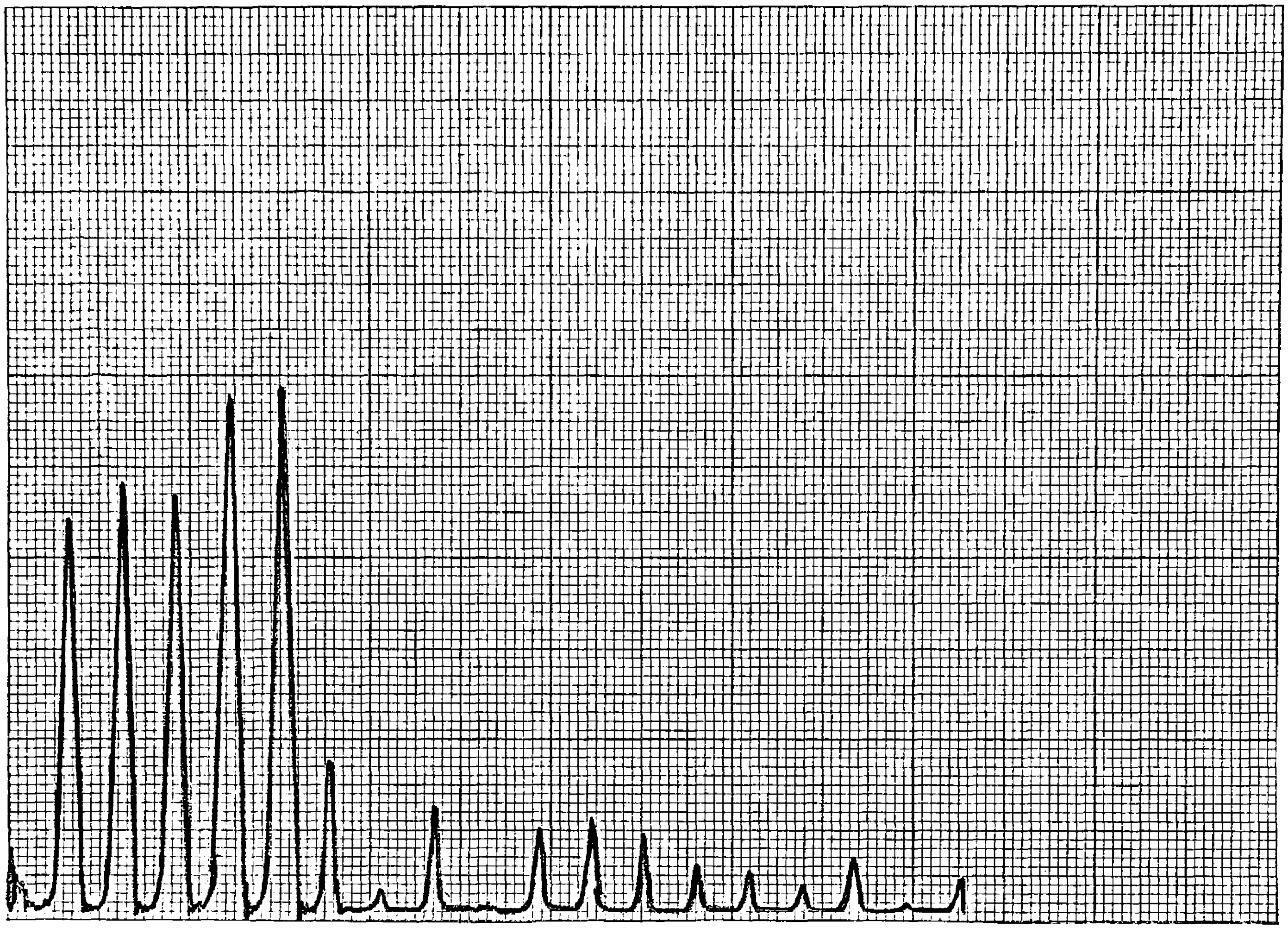
Spectrum Analysis Graph: Group I, Subject Number 25, Pitch f.



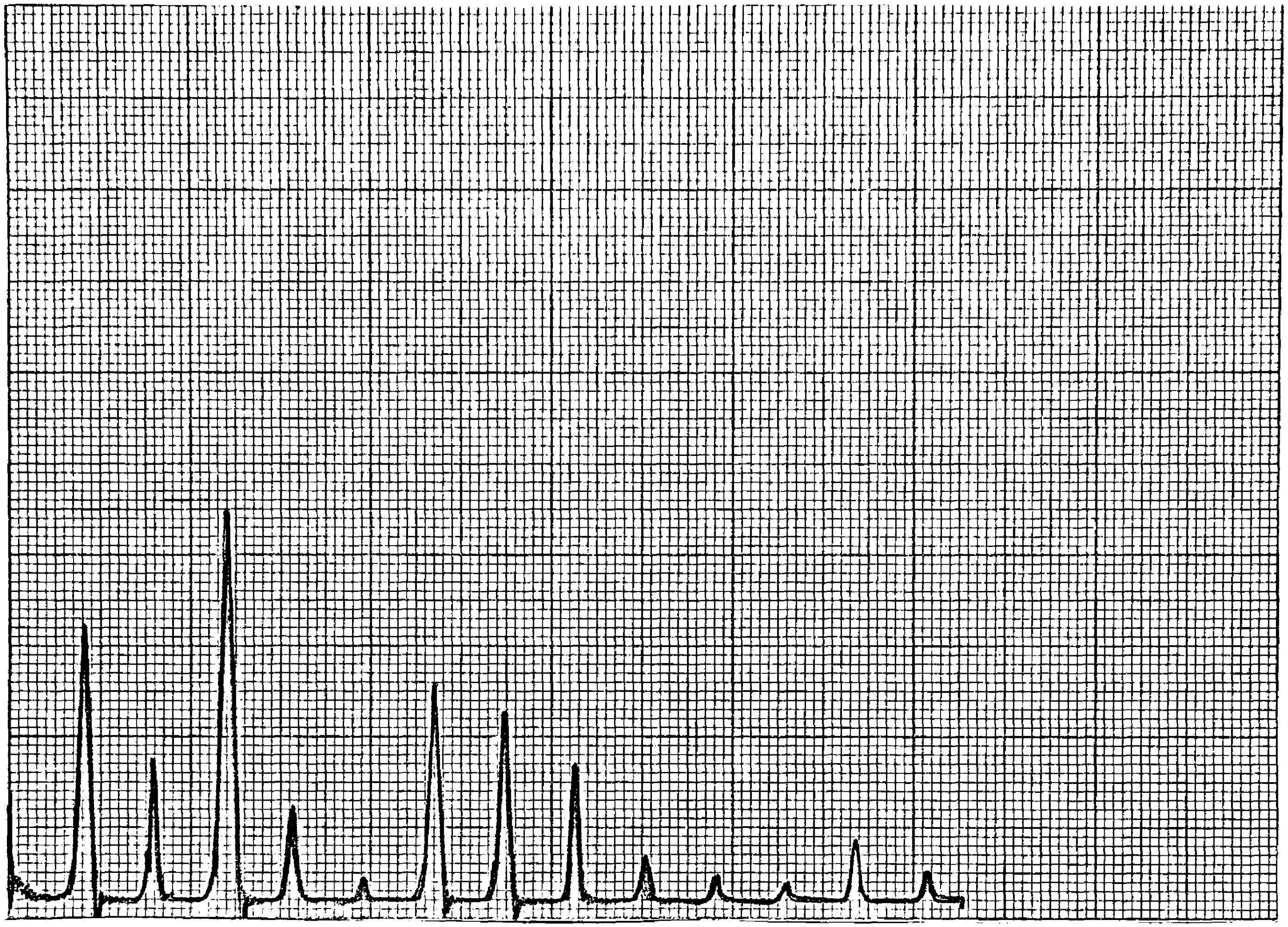
Spectrum Analysis Graph: Group I, Subject Number 25, Pitch b^b.



Spectrum Analysis Graph: Group I, Subject Number 25, Pitch e^{b}.



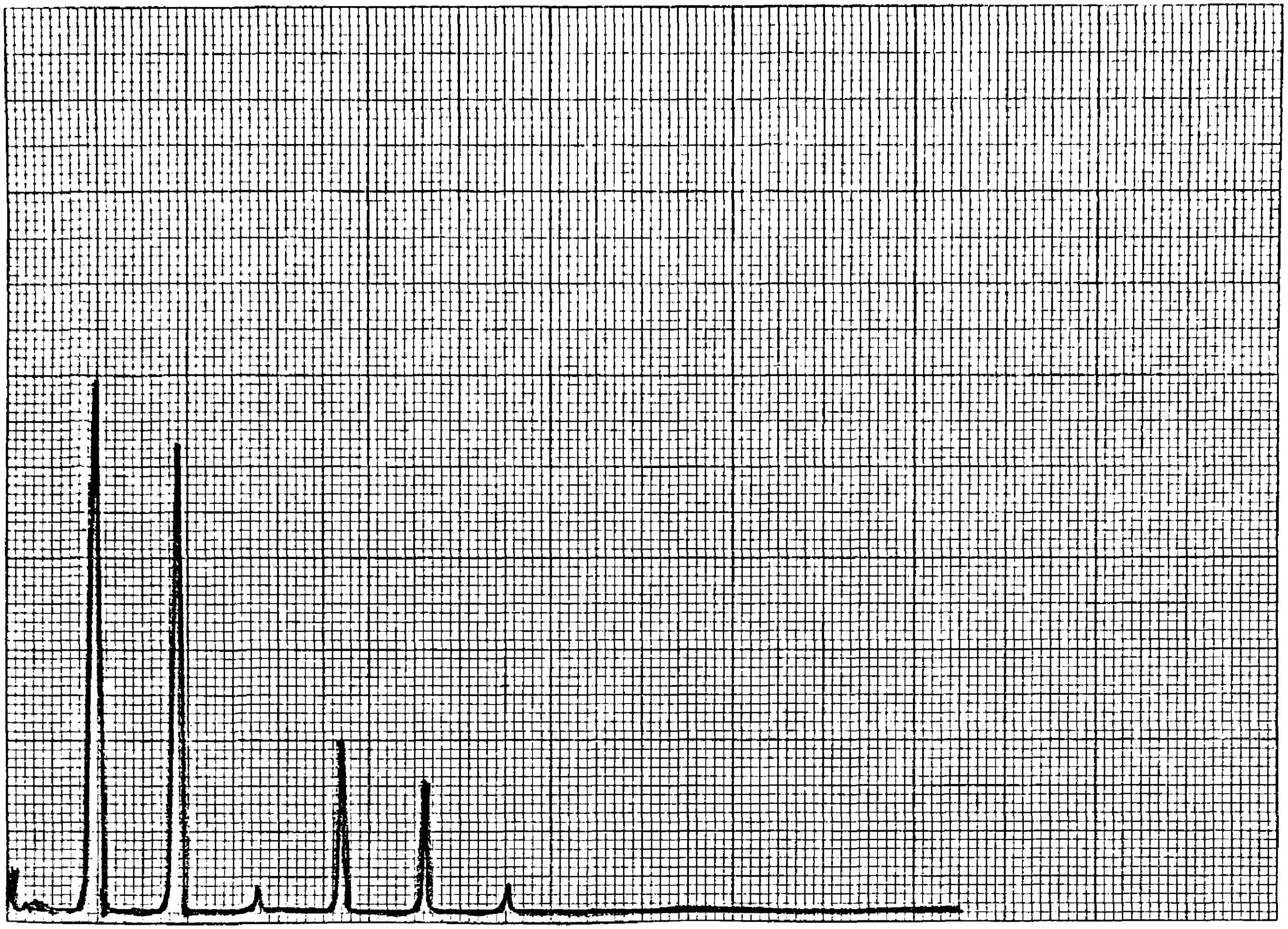
Spectrum Analysis Graph: Group I, Subject Number 26, Pitch d.



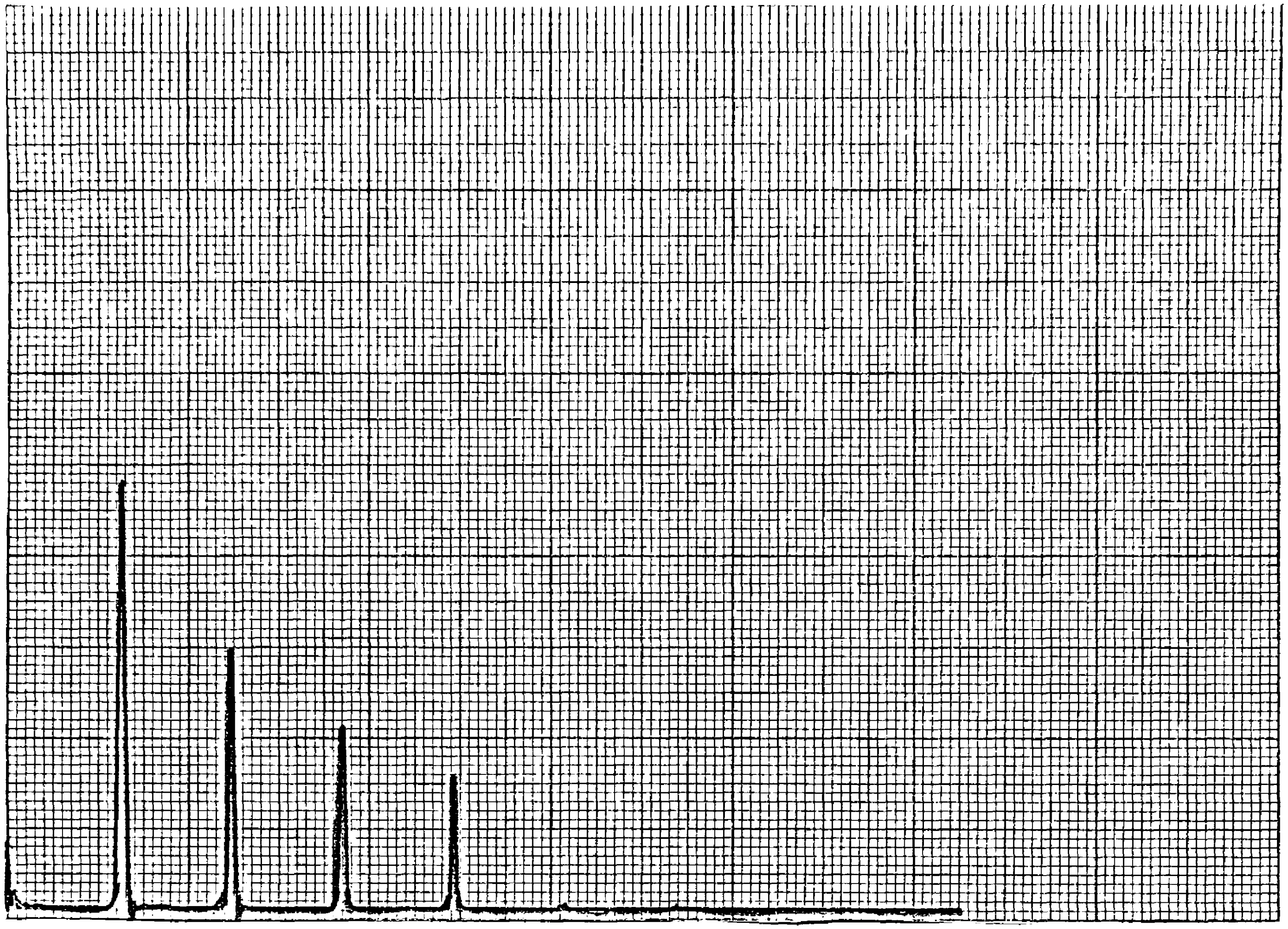
Spectrum Analysis Graph: Group I, Subject Number 26, Pitch g.

Spectrum Analysis Graph: Group I, Subject Number 26, Pitch c.

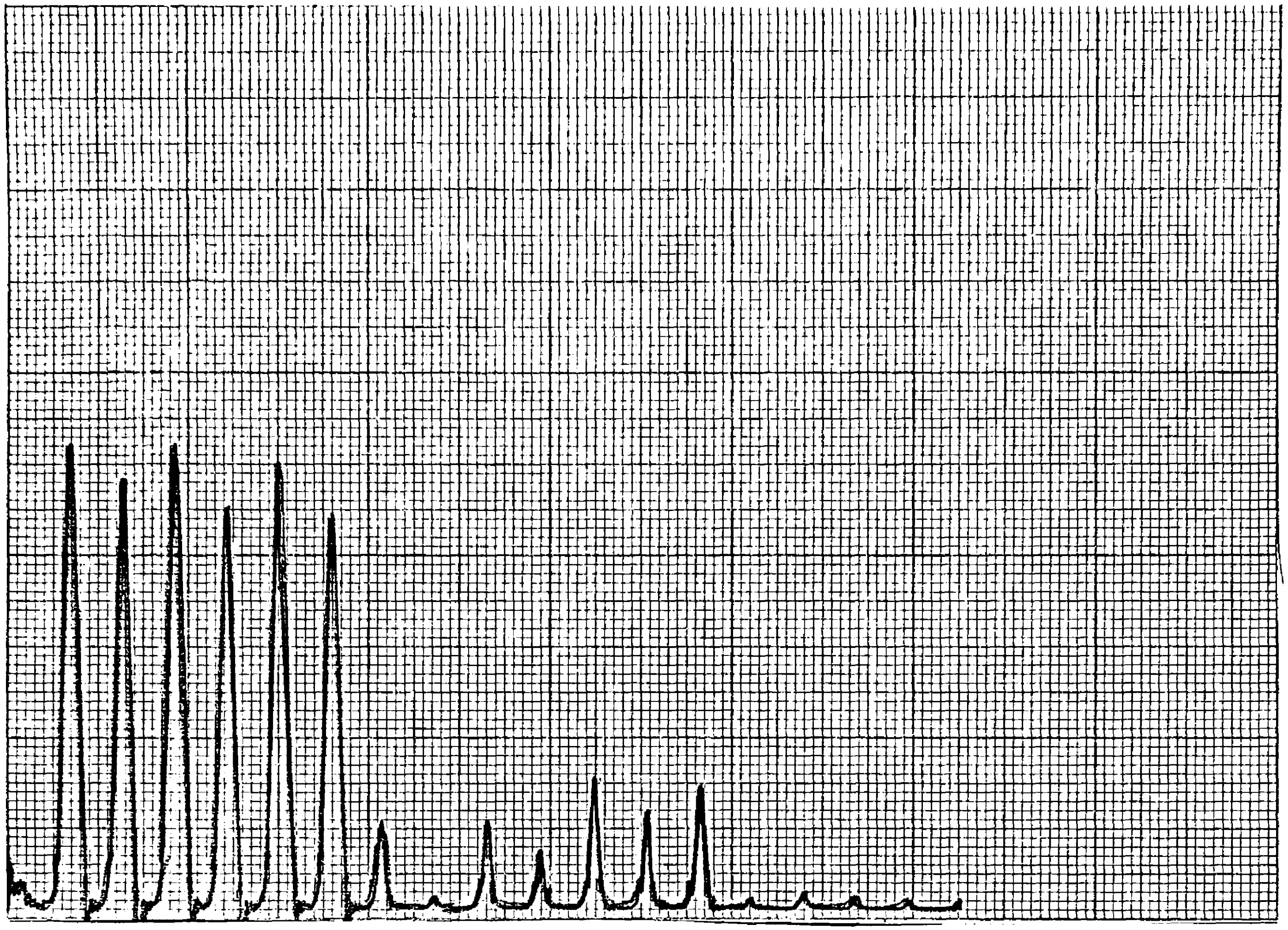
Spectrum Analysis Graph: Group I, Subject Number 26, Pitch f.



Spectrum Analysis Graph: Group I, Subject Number 26, Pitch b^b.



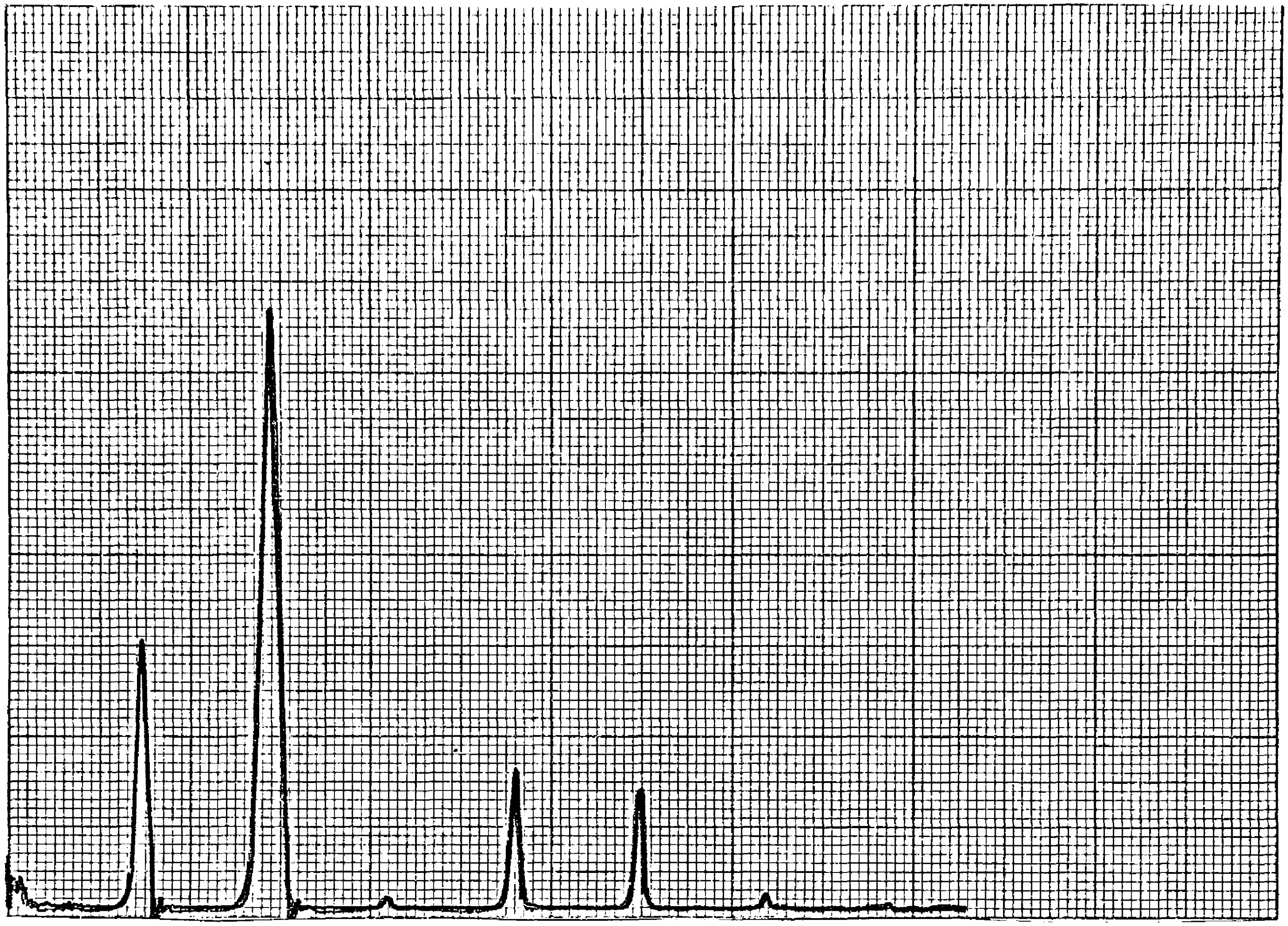
Spectrum Analysis Graph: Group I, Subject Number 26, Pitch e^{b}.



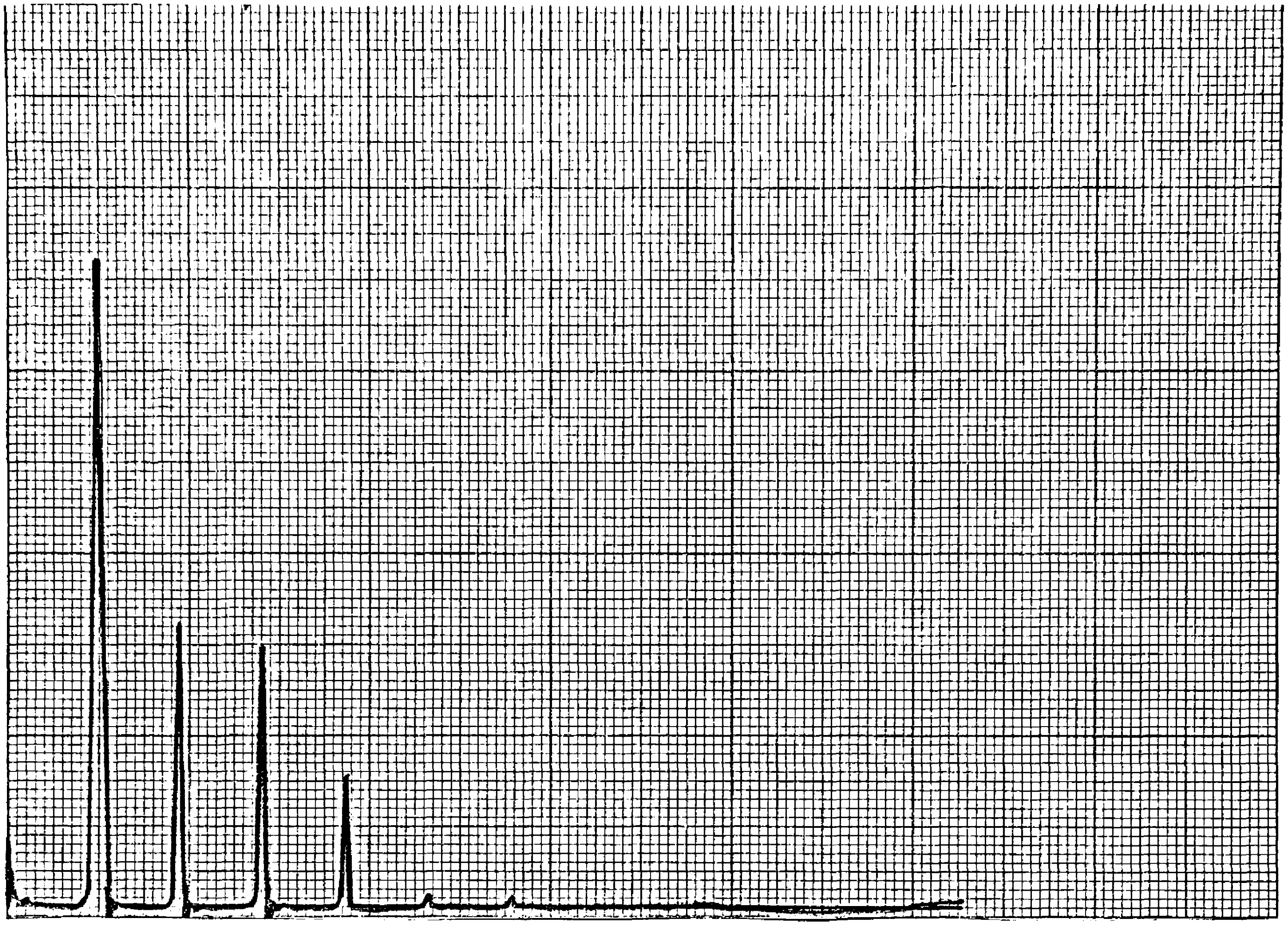
Spectrum Analysis Graph: Group I, Subject Number 27, Pitch d.

Spectrum Analysis Graph: Group I, Subject Number 27, Pitch g.

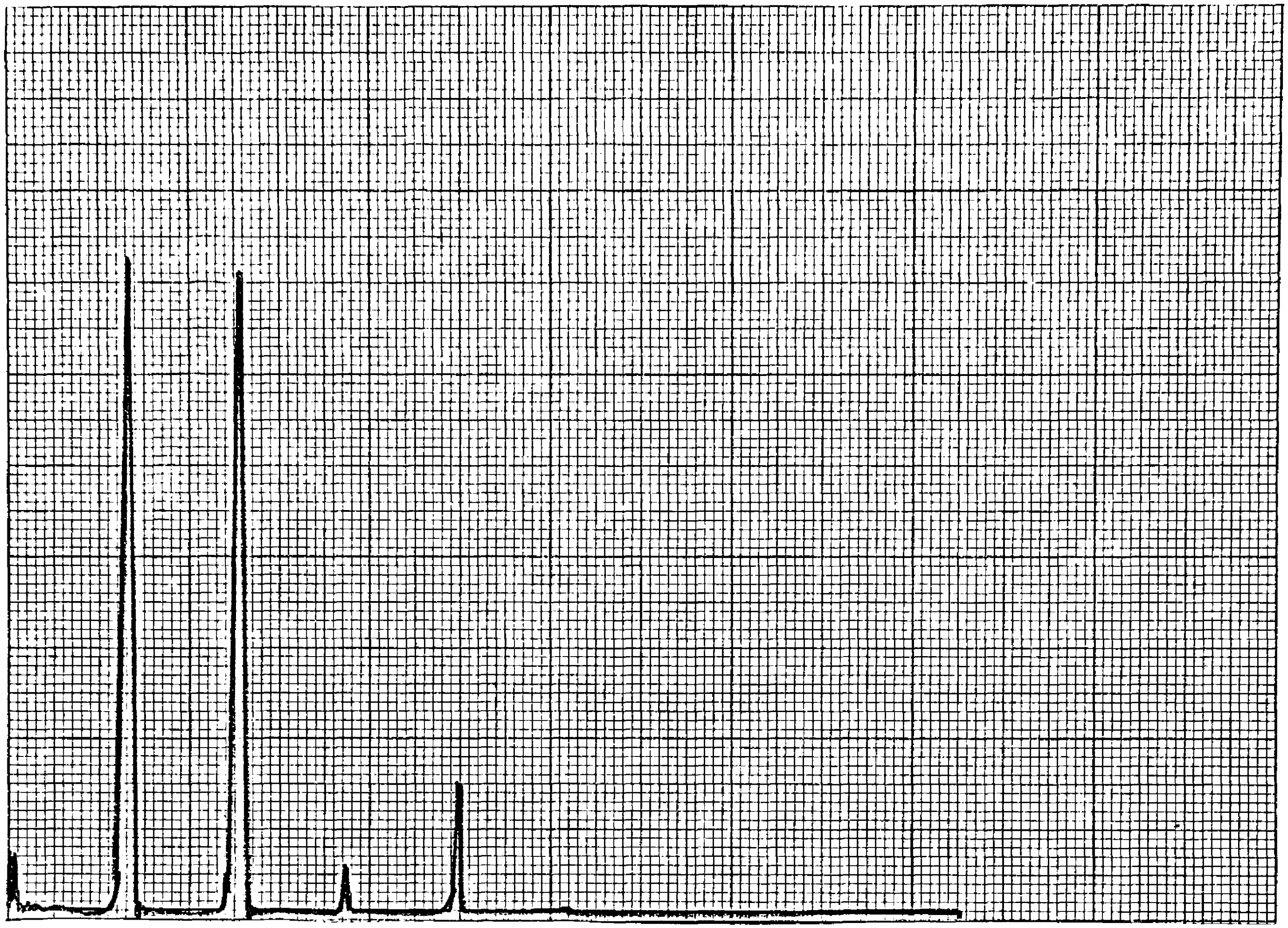
Spectrum Analysis Graph: Group I, Subject Number 27, Pitch c.



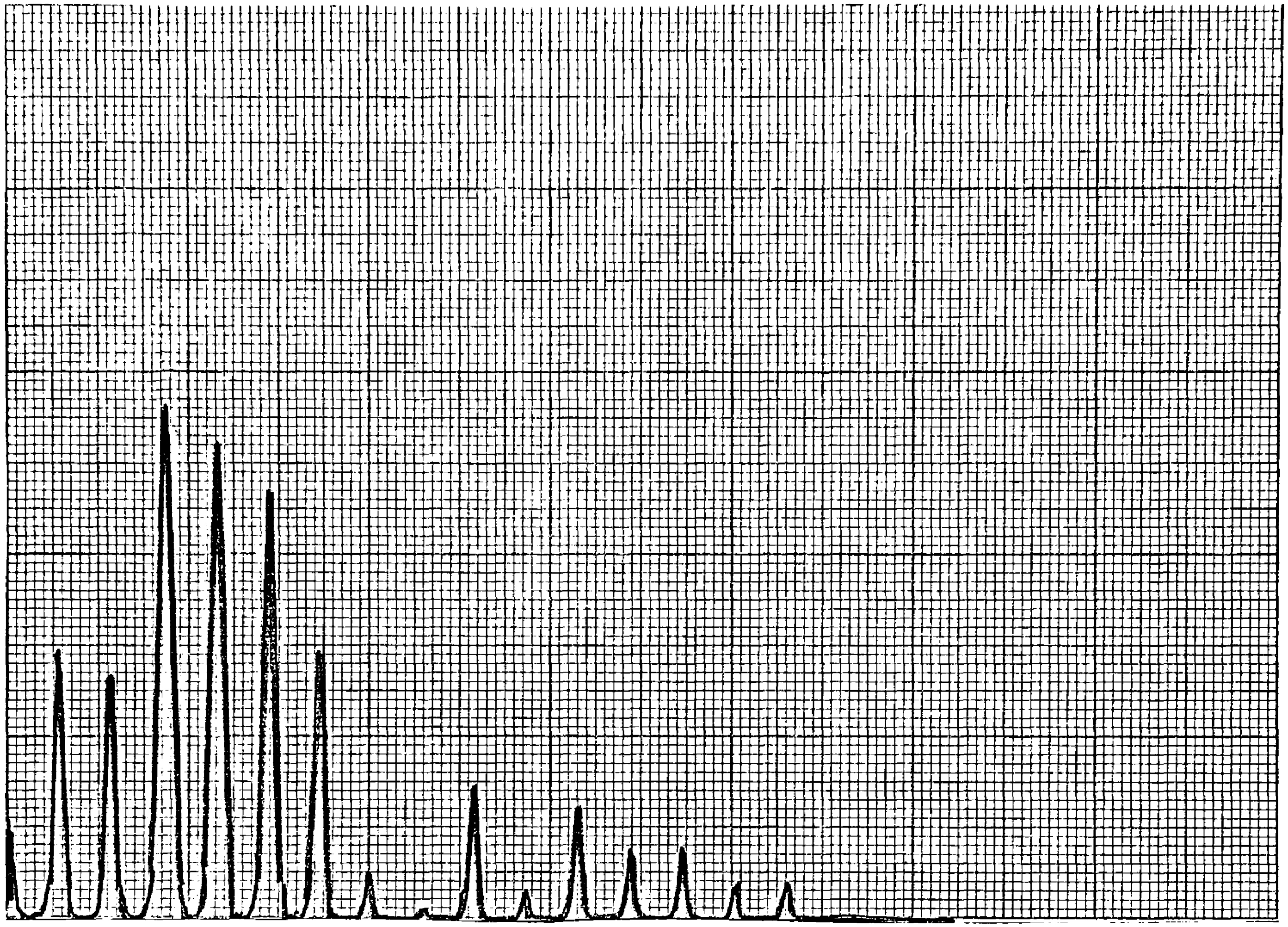
Spectrum Analysis Graph: Group I, Subject Number 27, Pitch f.



Spectrum Analysis Graph: Group I, Subject Number 27, Pitch b^b.



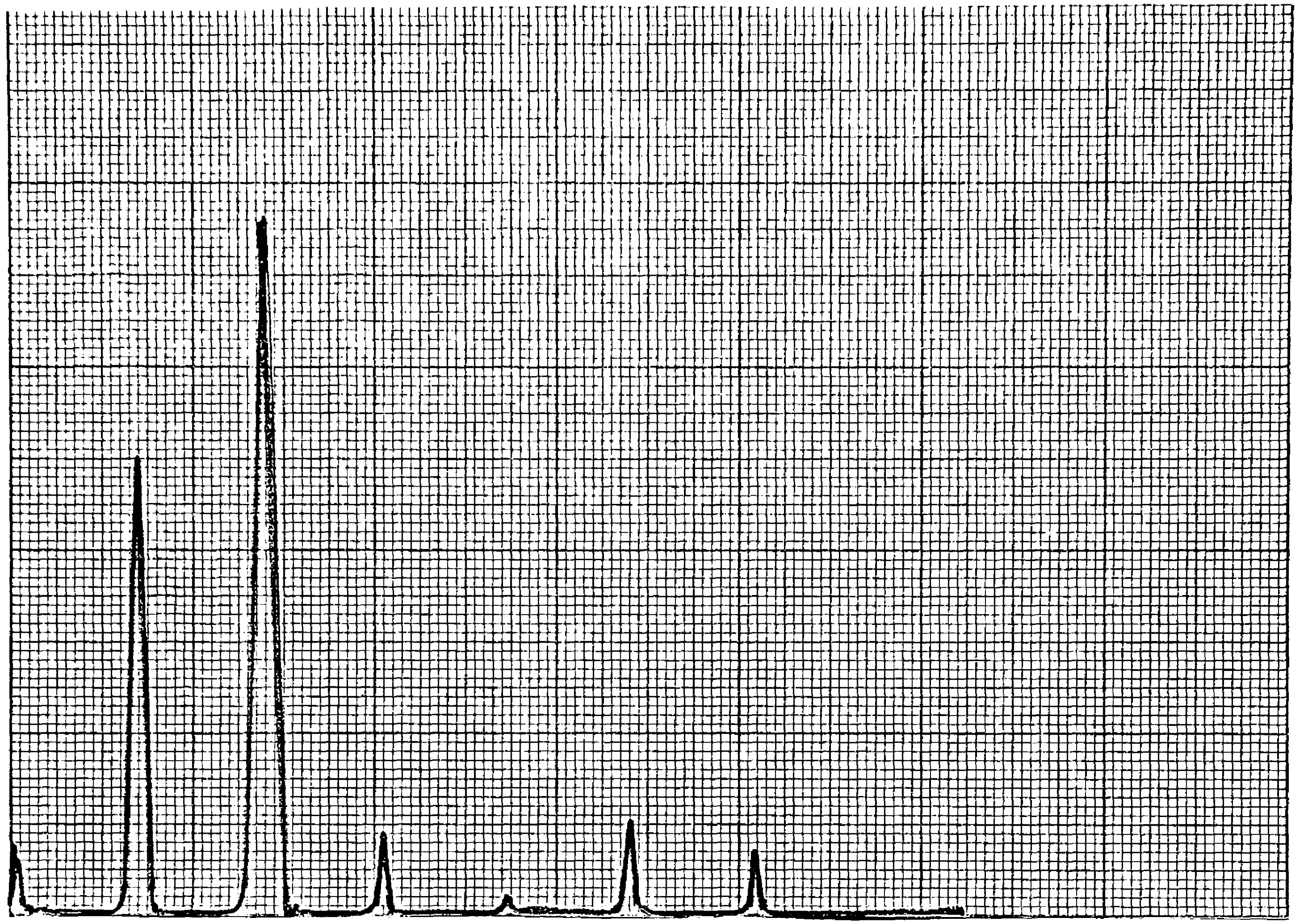
Spectrum Analysis Graph: Group I, Subject Number 27, Pitch e[b].



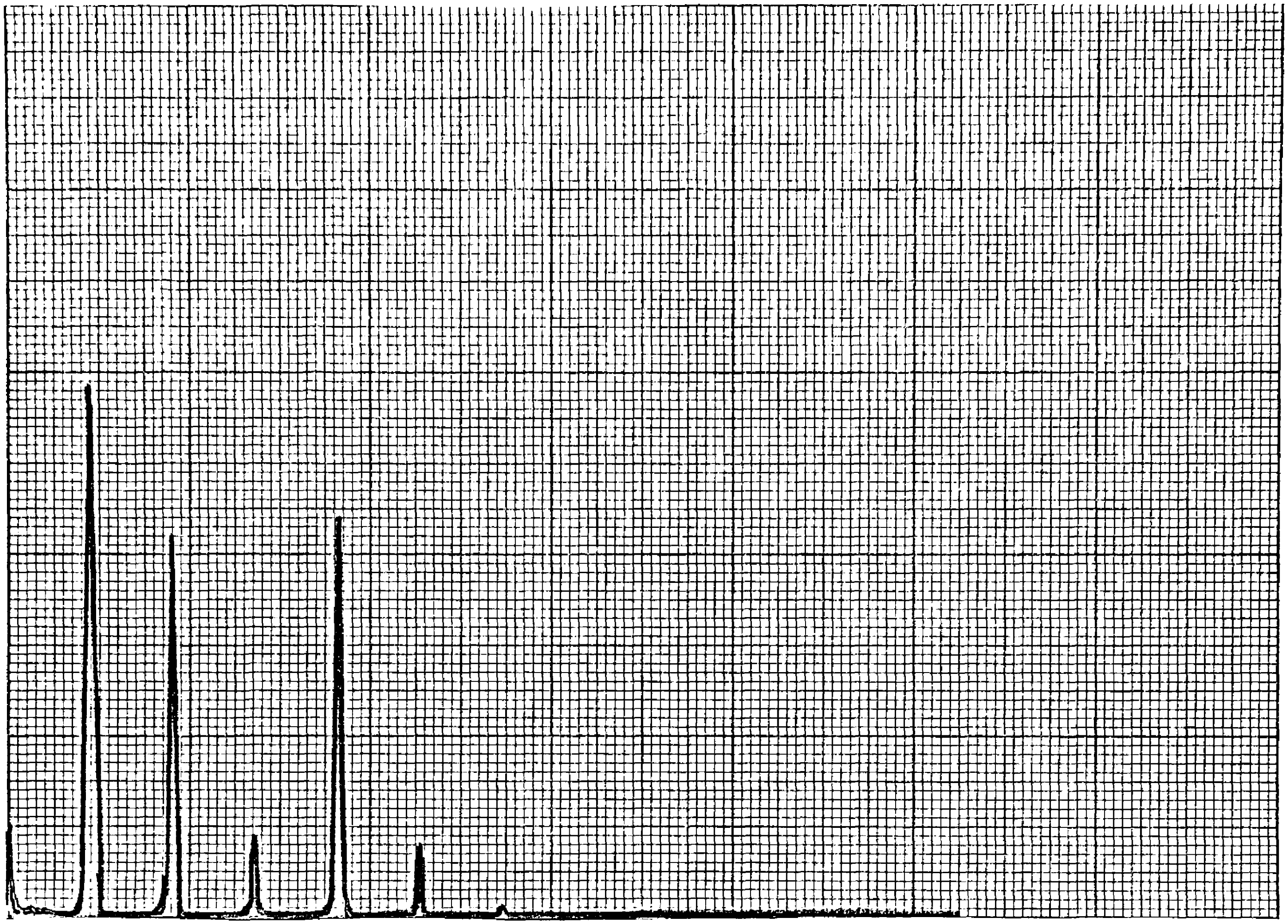
Spectrum Analysis Graph: Group I, Subject Number 37, Pitch d.

Spectrum Analysis Graph: Group I, Subject Number 37, Pitch g.

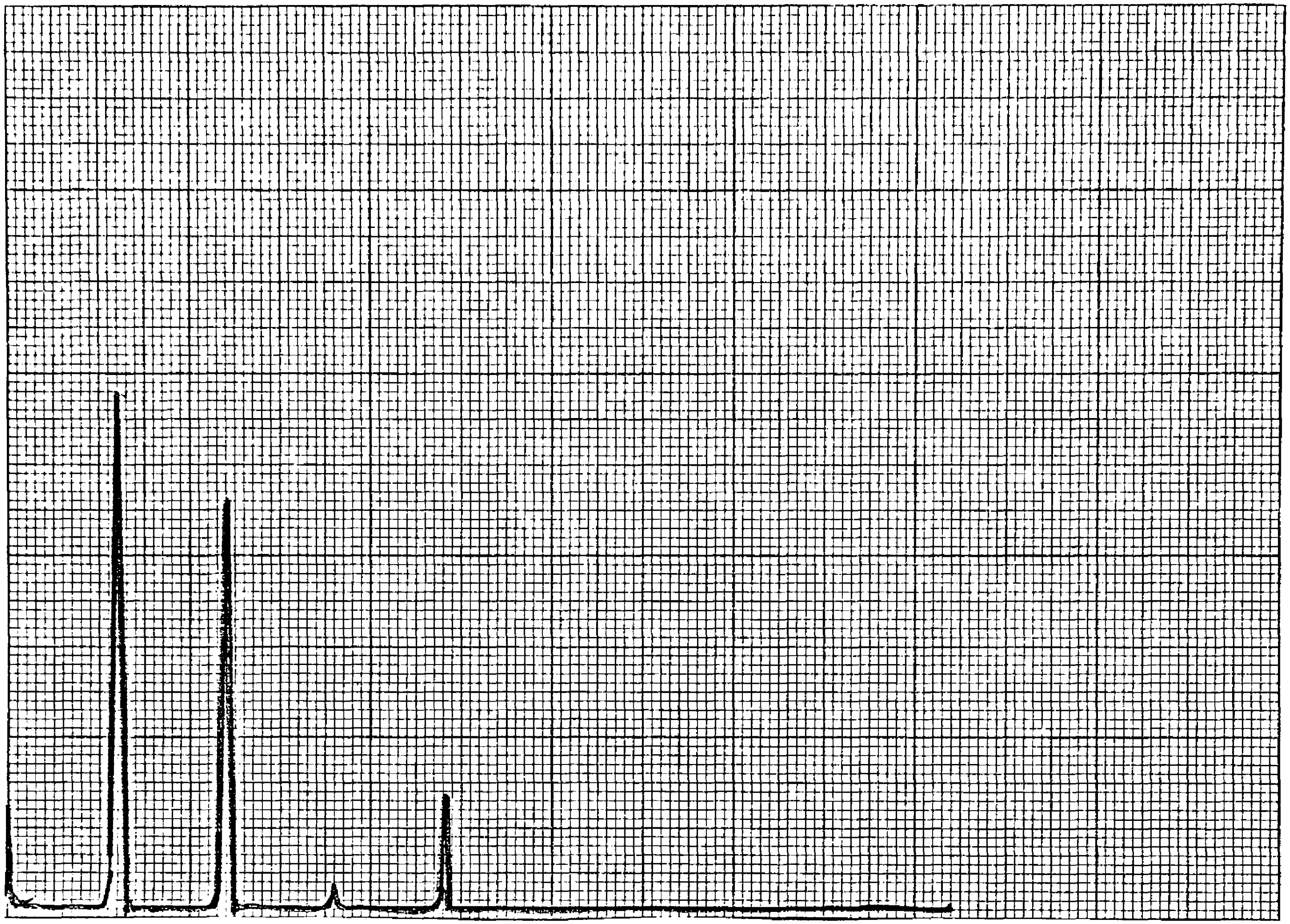
Spectrum Analysis Graph: Group I, Subject Number 37, Pitch c.



Spectrum Analysis Graph: Group I, Subject Number 37, Pitch f.

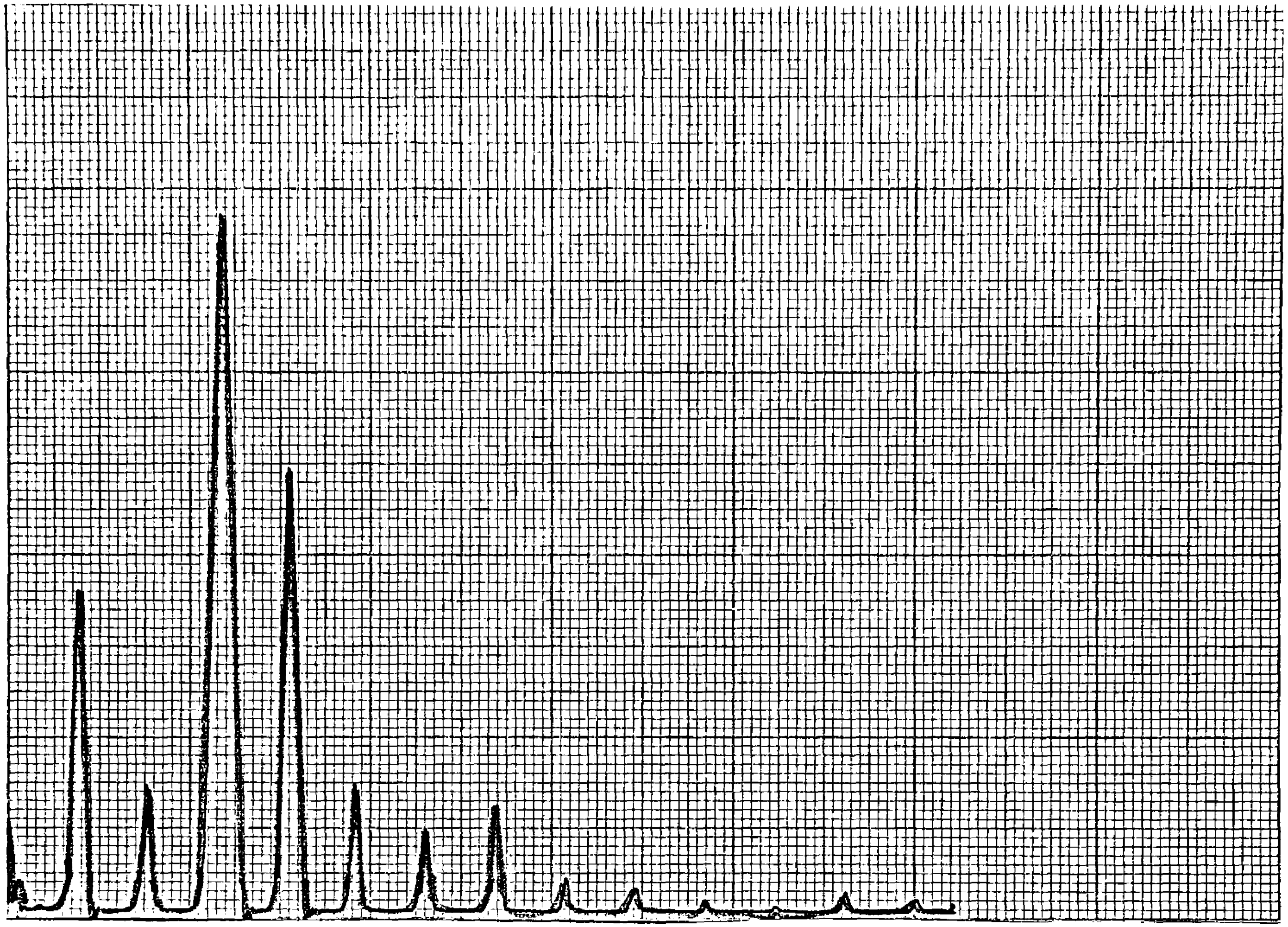


Spectrum Analysis Graph: Group I, Subject Number 37, Pitch b^{b}.



Spectrum Analysis Graph: Group I, Subject Number 37, Pitch e^{b}.

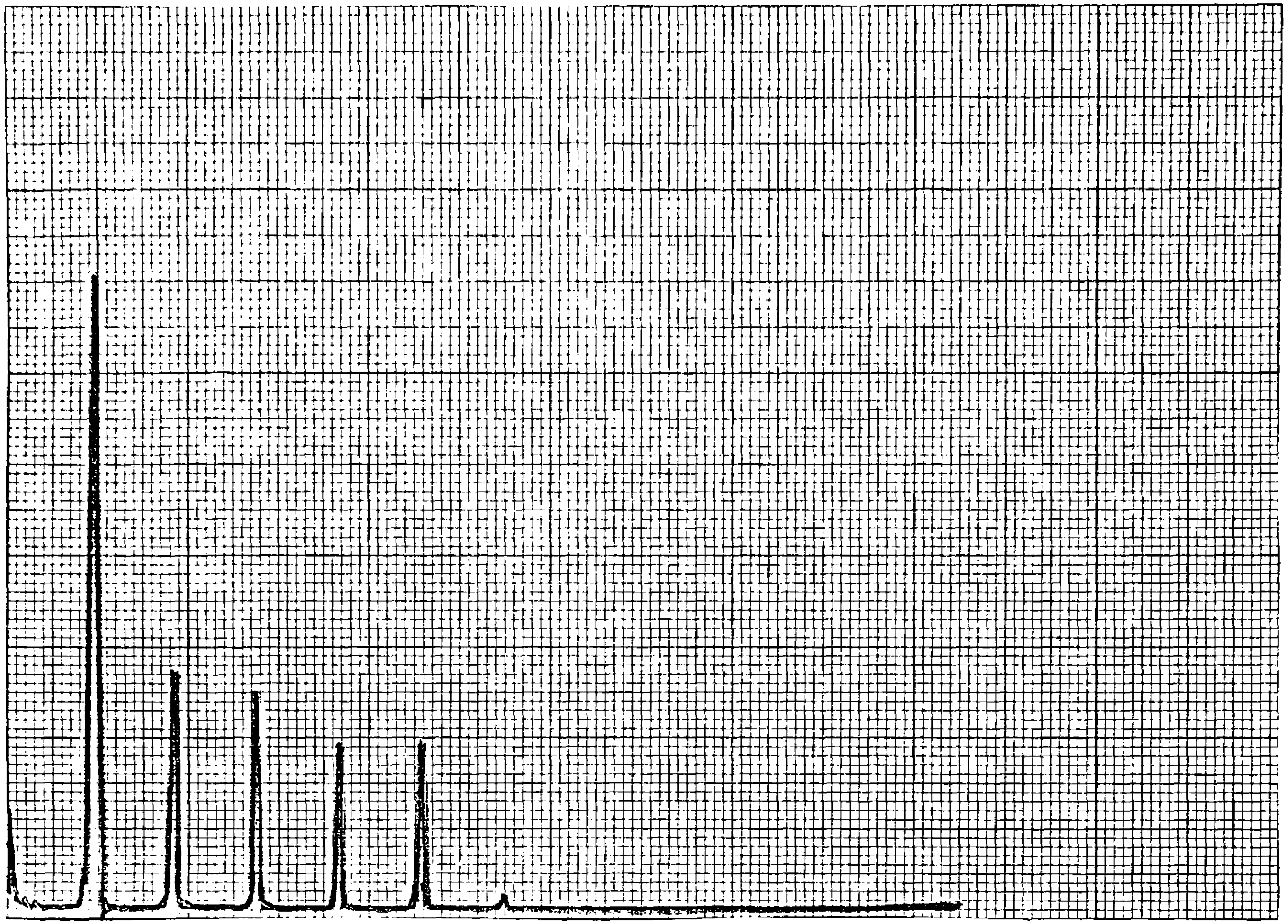
Spectrum Analysis Graph: Group I, Subject Number 38, Pitch d.



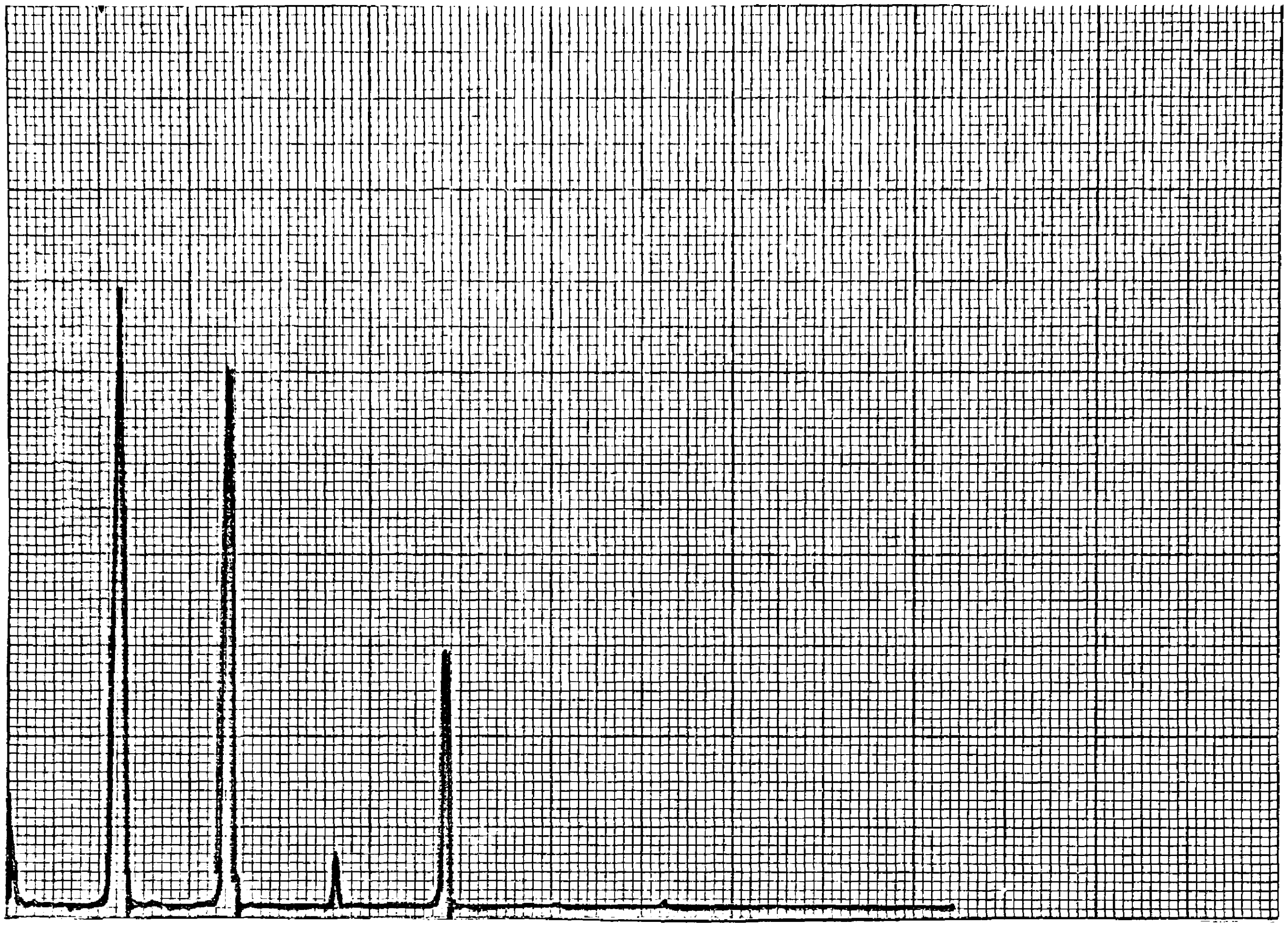
Spectrum Analysis Graph: Group I, Subject Number 38, Pitch g.

Spectrum Analysis Graph: Group I, Pitch Number 38, Pitch c.

Spectrum Analysis Graph: Group I, Subject Number 38, Pitch f.

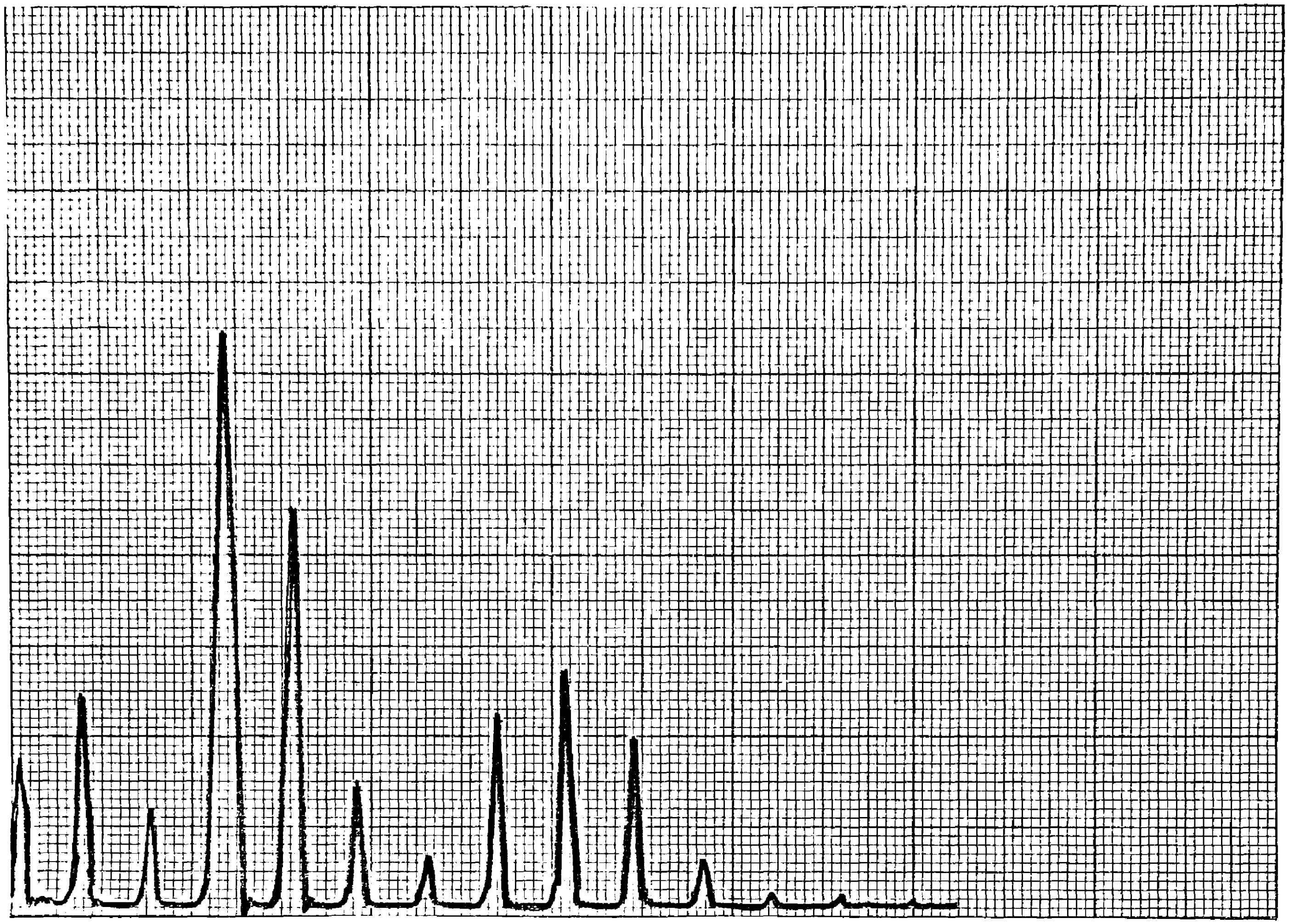


Spectrum Analysis Graph: Group I, Subject Number 38, Pitch b^b.

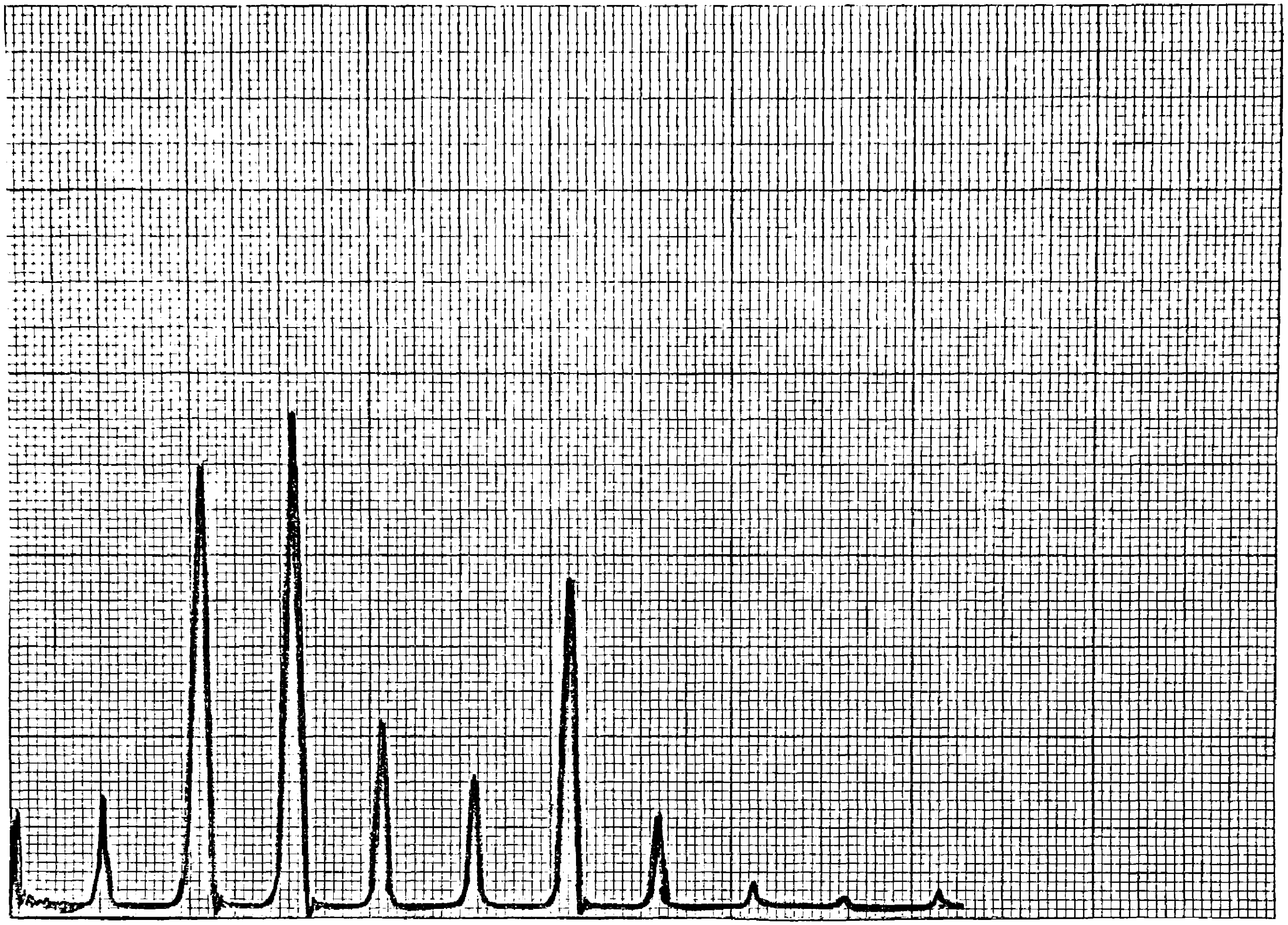


Spectrum Analysis Graph: Group I, Subject Number 38, Pitch e^b.

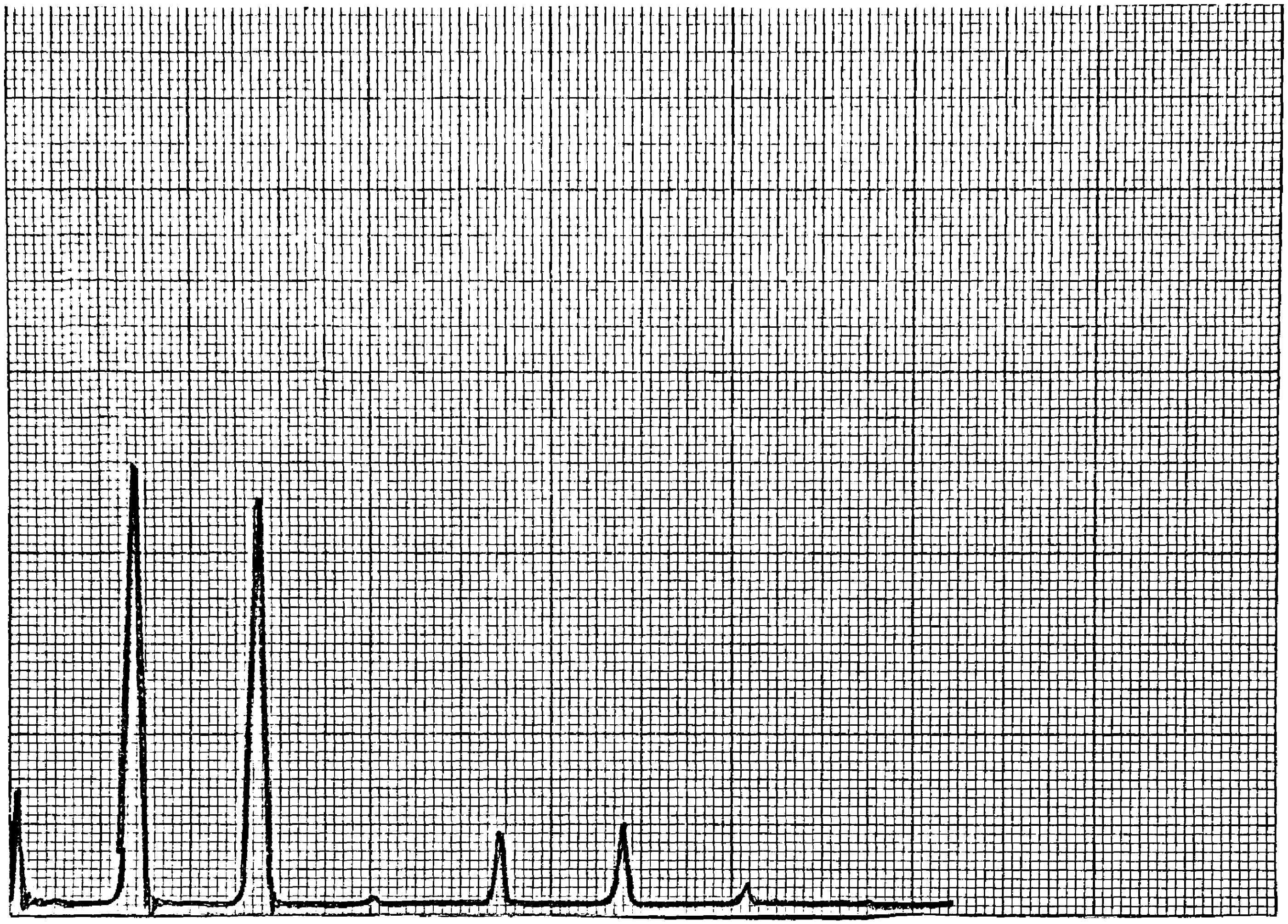
Spectrum Analysis Graph: Group I, Subject Number 39, Pitch d.



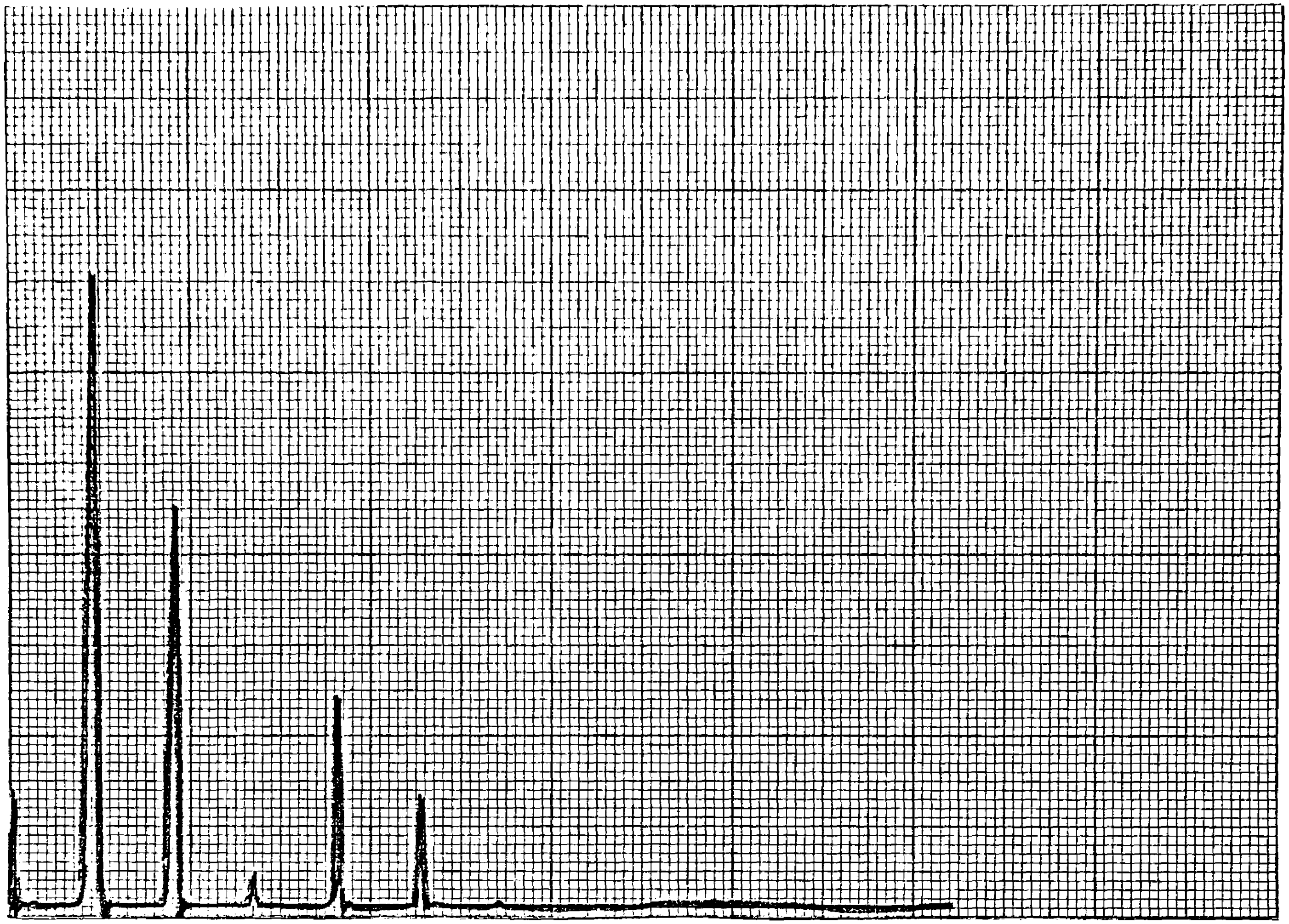
Spectrum Analysis Graph: Group I, Subject Number 39, Pitch g.



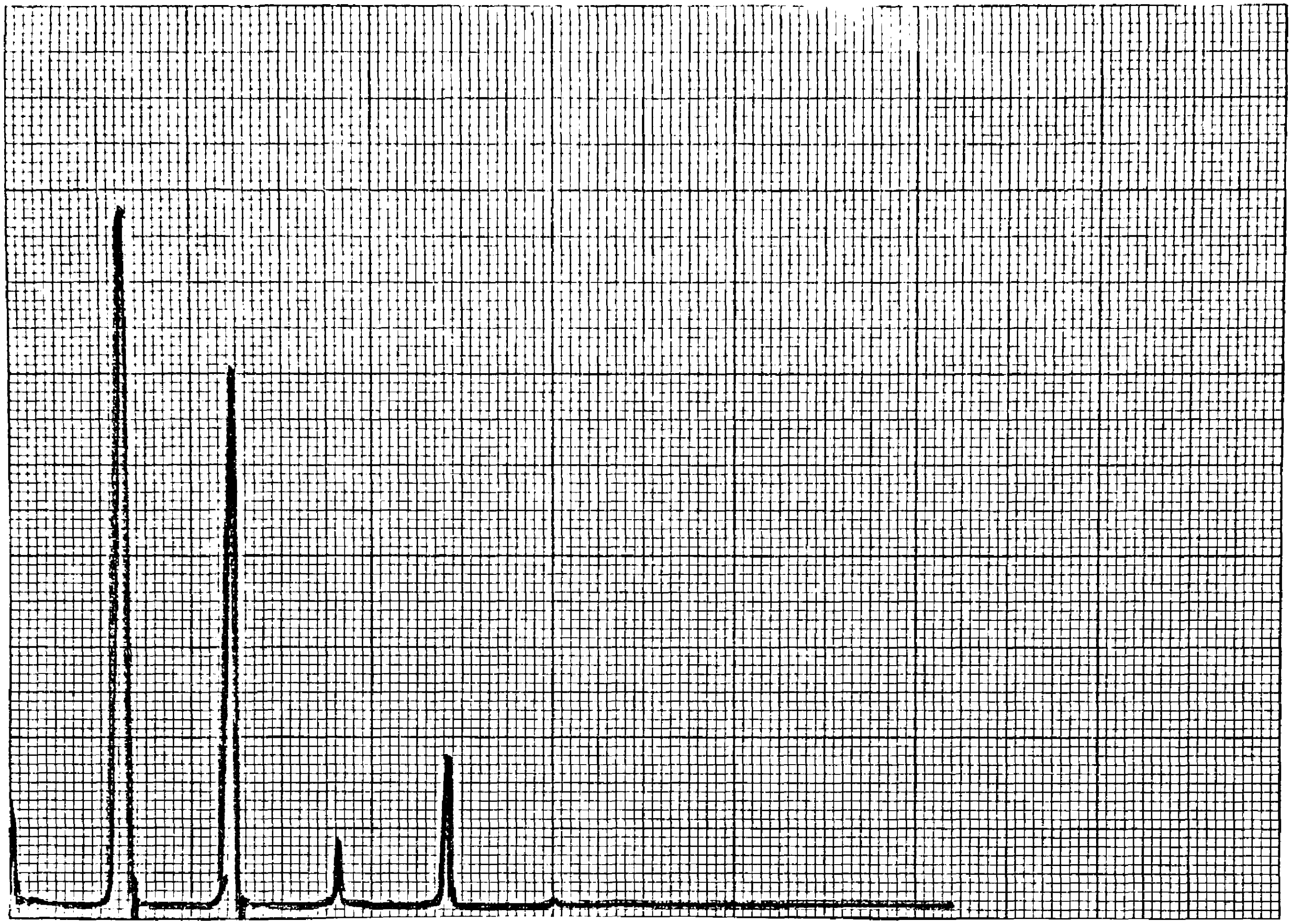
Spectrum Analysis Graph: Group I, Subject Number 39, Pitch c.



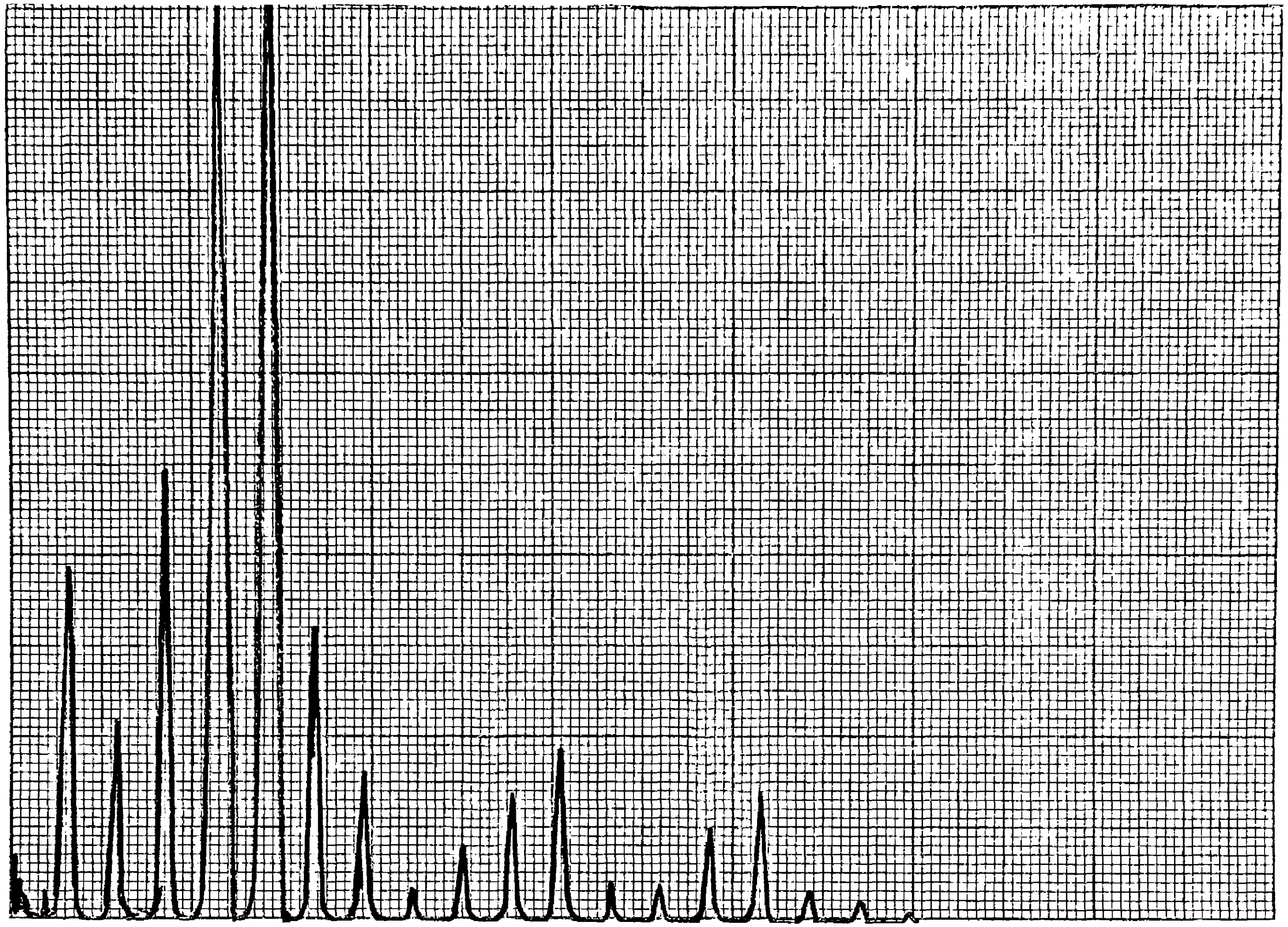
Spectrum Analysis Graph: Group I, Subject Number 39, Pitch f.



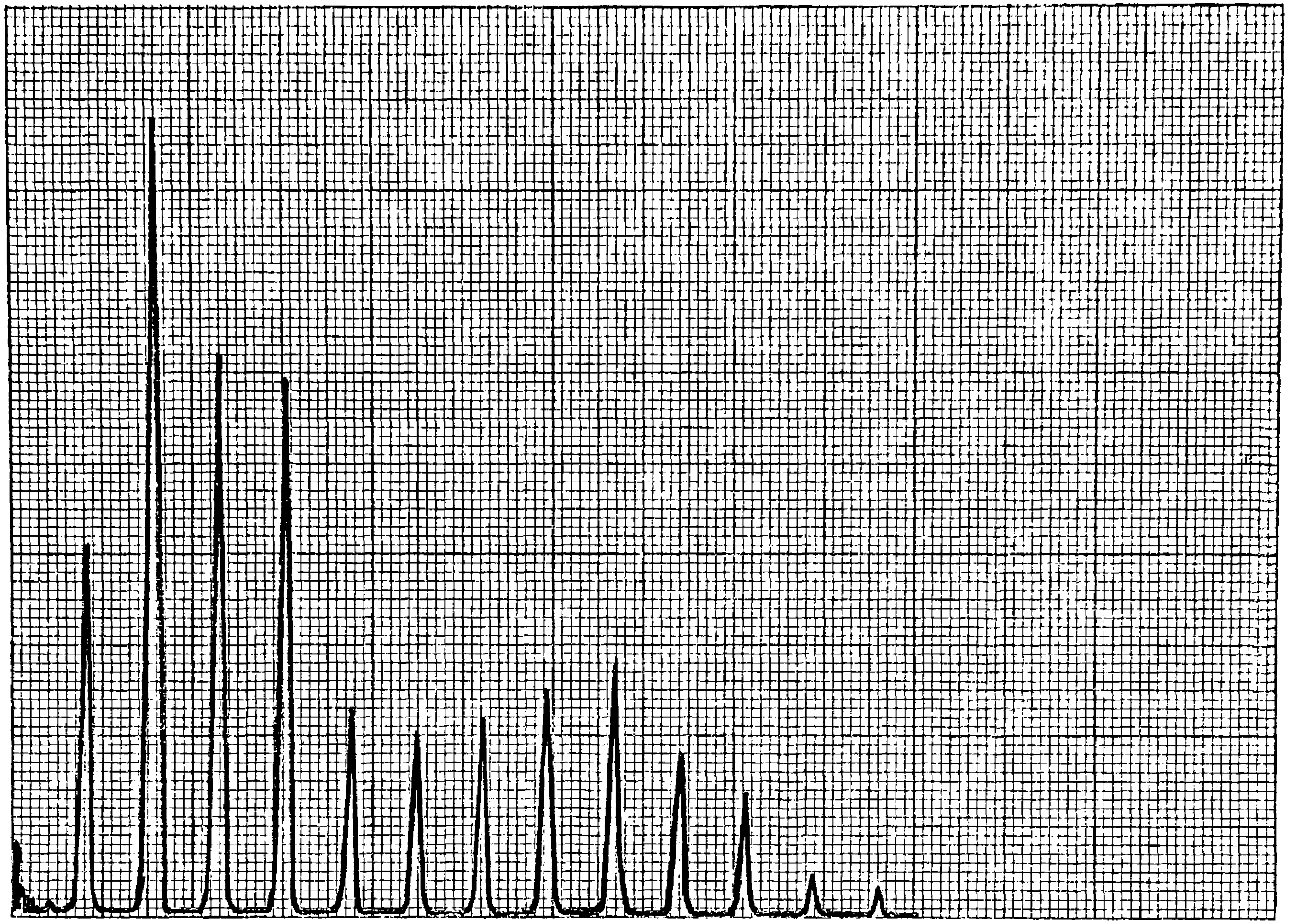
Spectrum Analysis Graph: Group I, Subject Number 39, Pitch b^b.



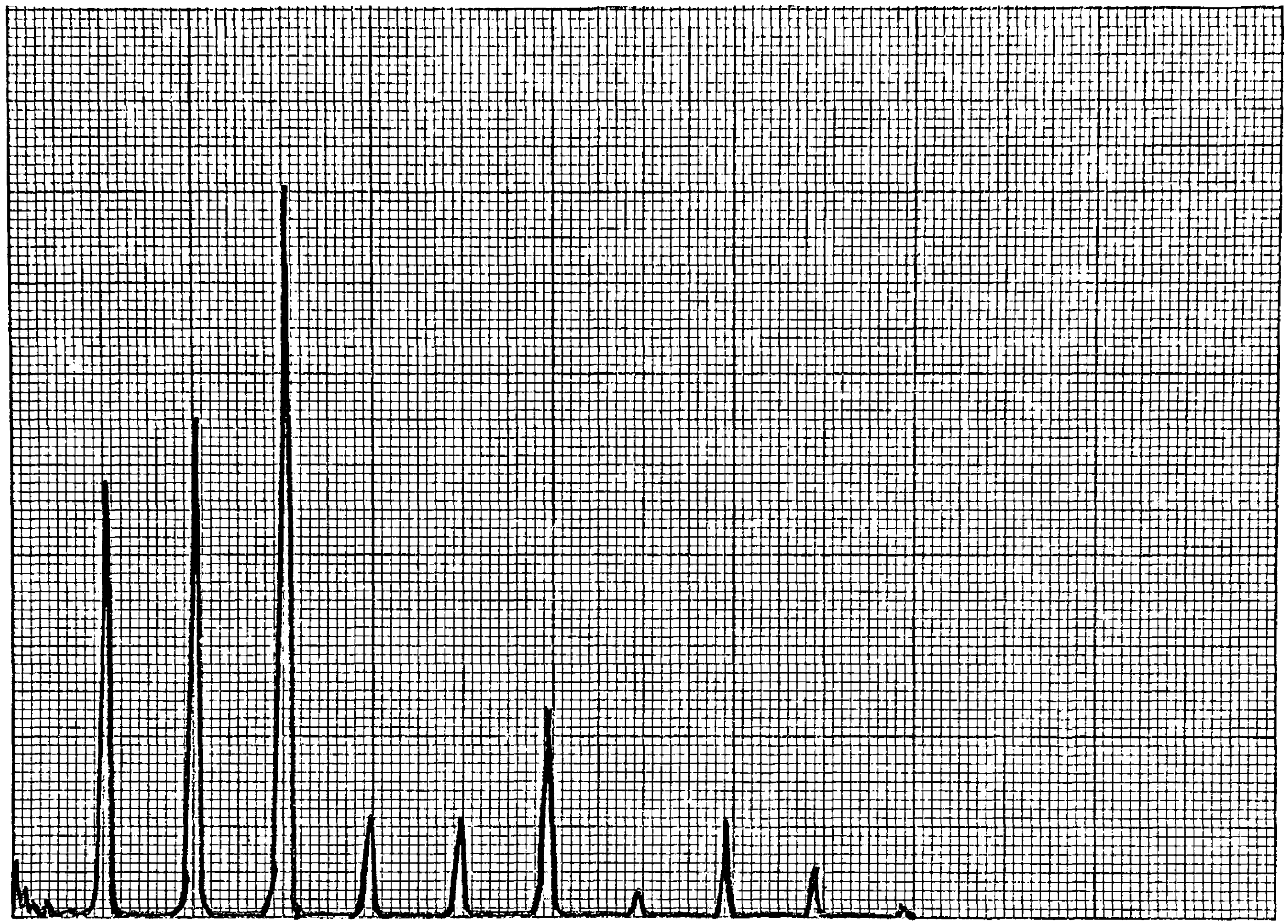
Spectrum Analysis Graph: Group I, Subject Number 39, Pitch e^{b}.



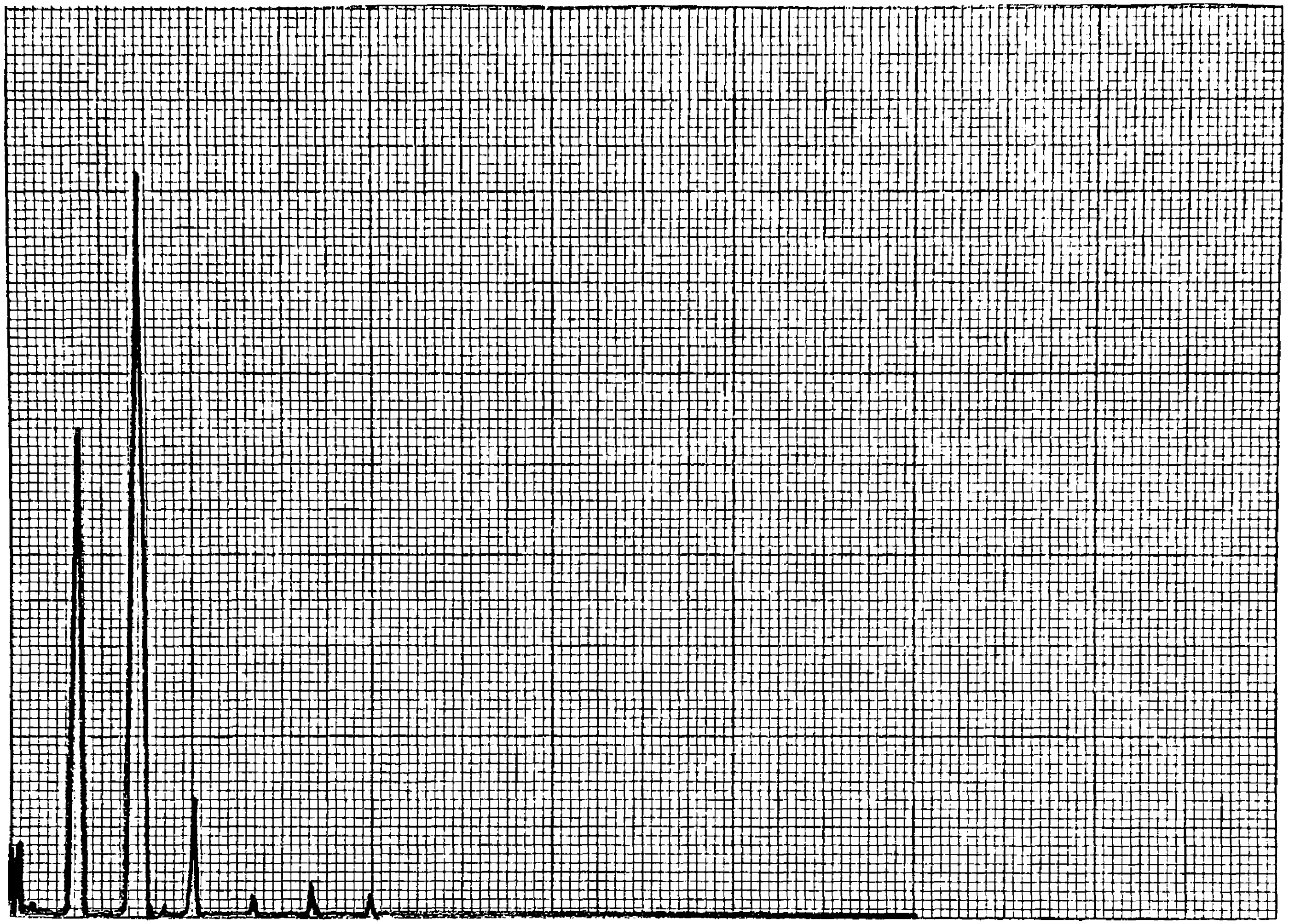
Spectrum Analysis Graph: Group II, Subject Number 4, Pitch d.



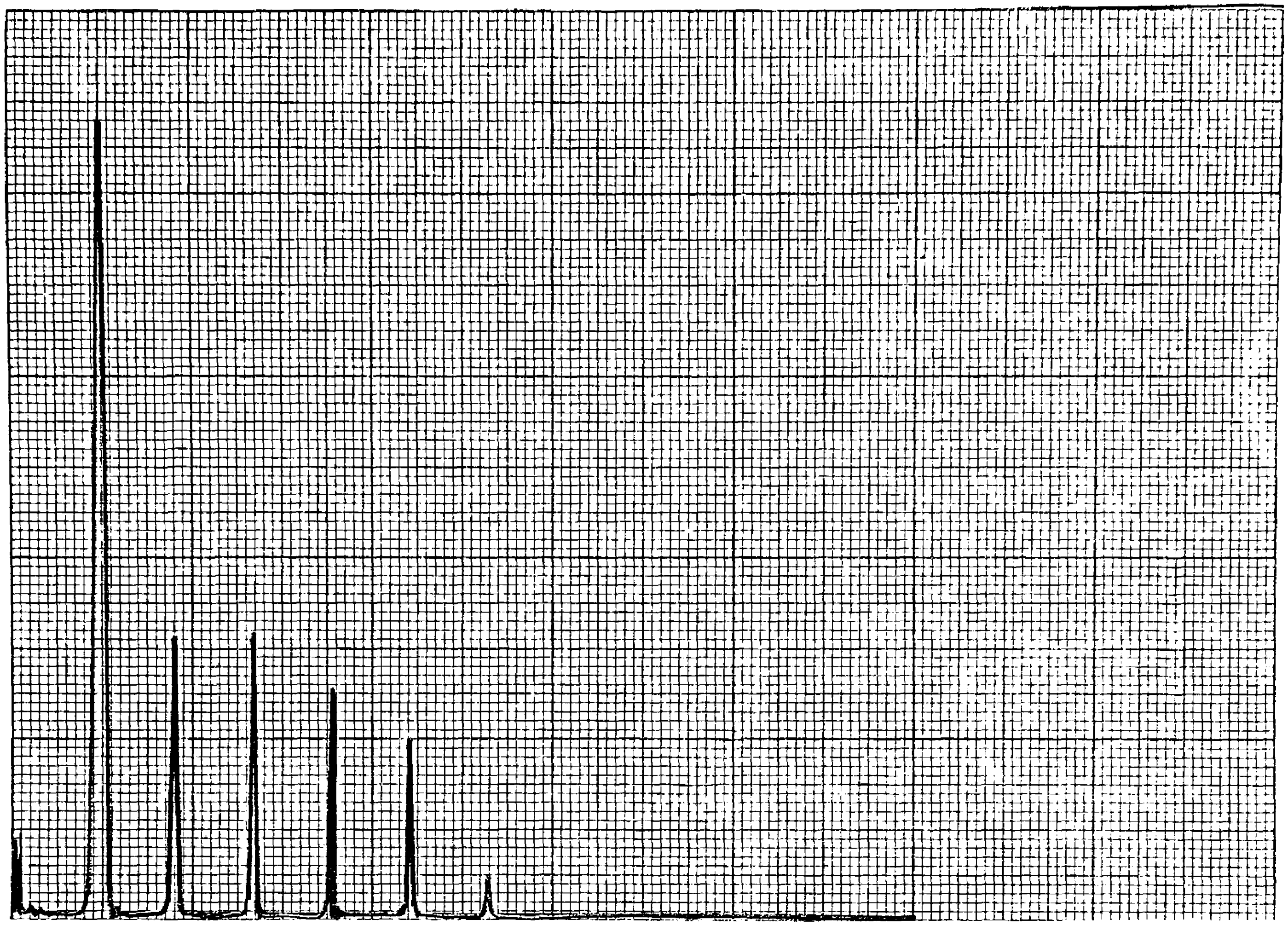
Spectrum Analysis Graph: Group II, Subject Number 4, Pitch g.



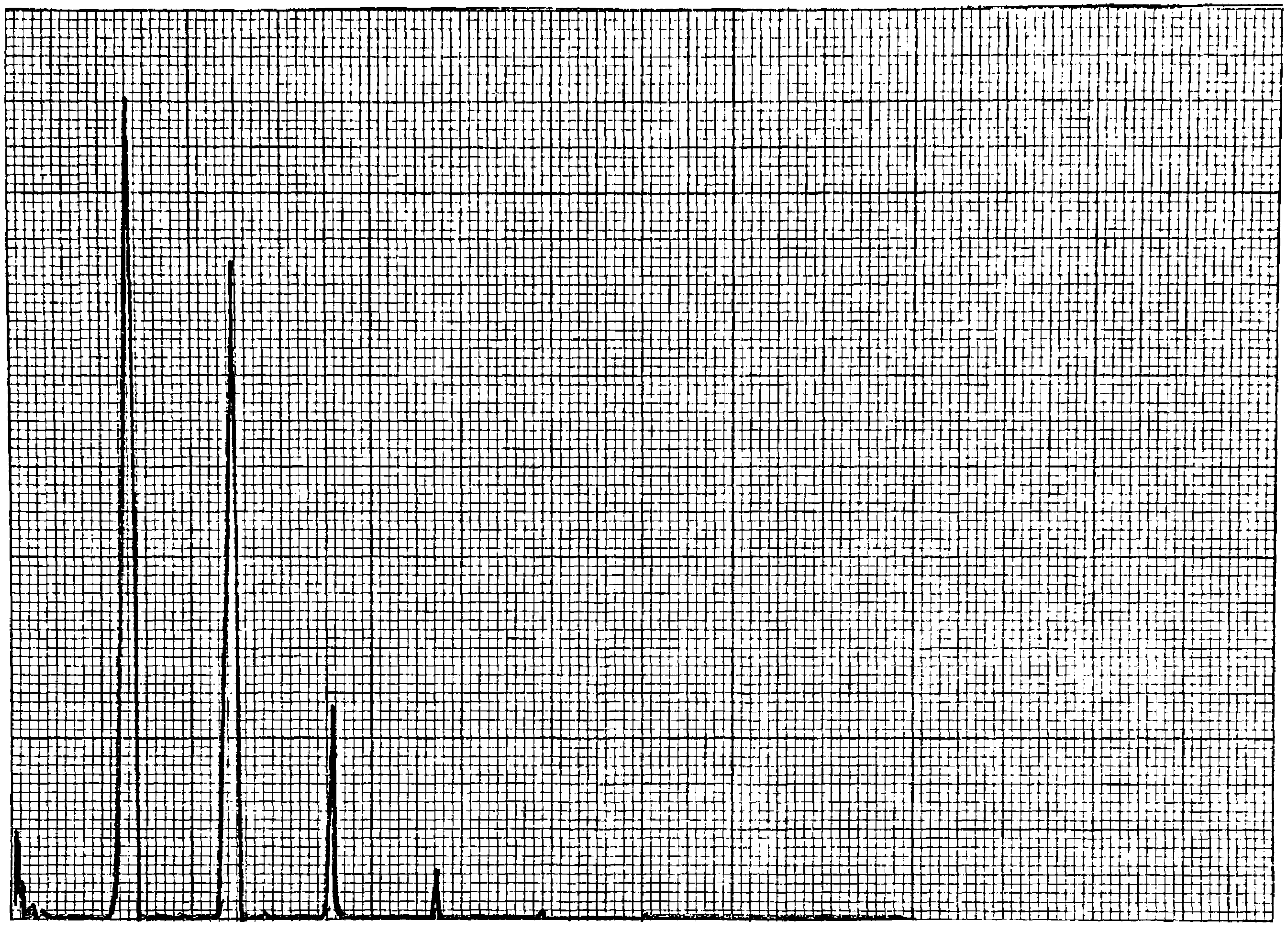
Spectrum Analysis Graph: Group II, Subject Number 4, Pitch c.



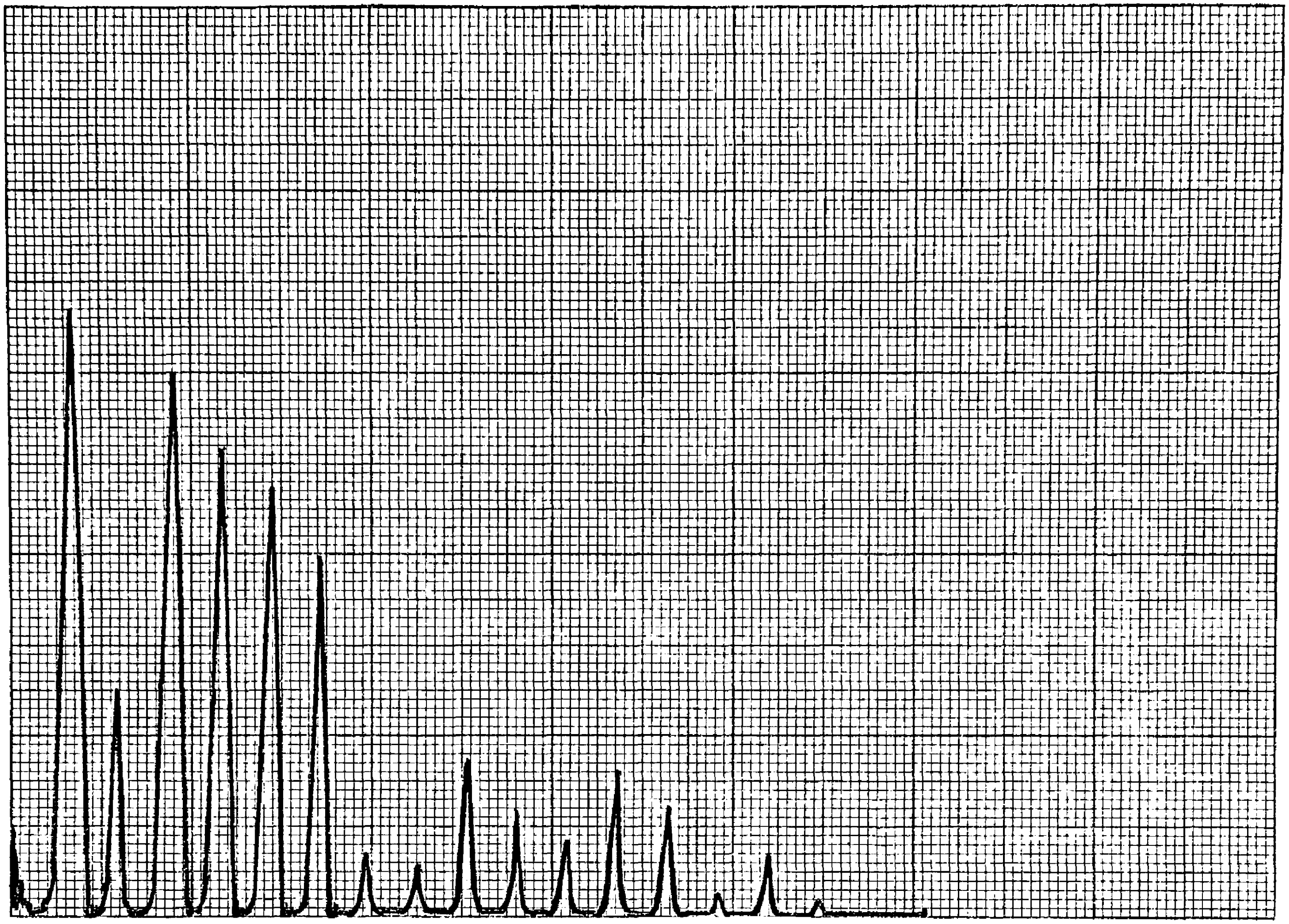
Spectrum Analysis Graph: Group II, Subject Number 4, Pitch f.



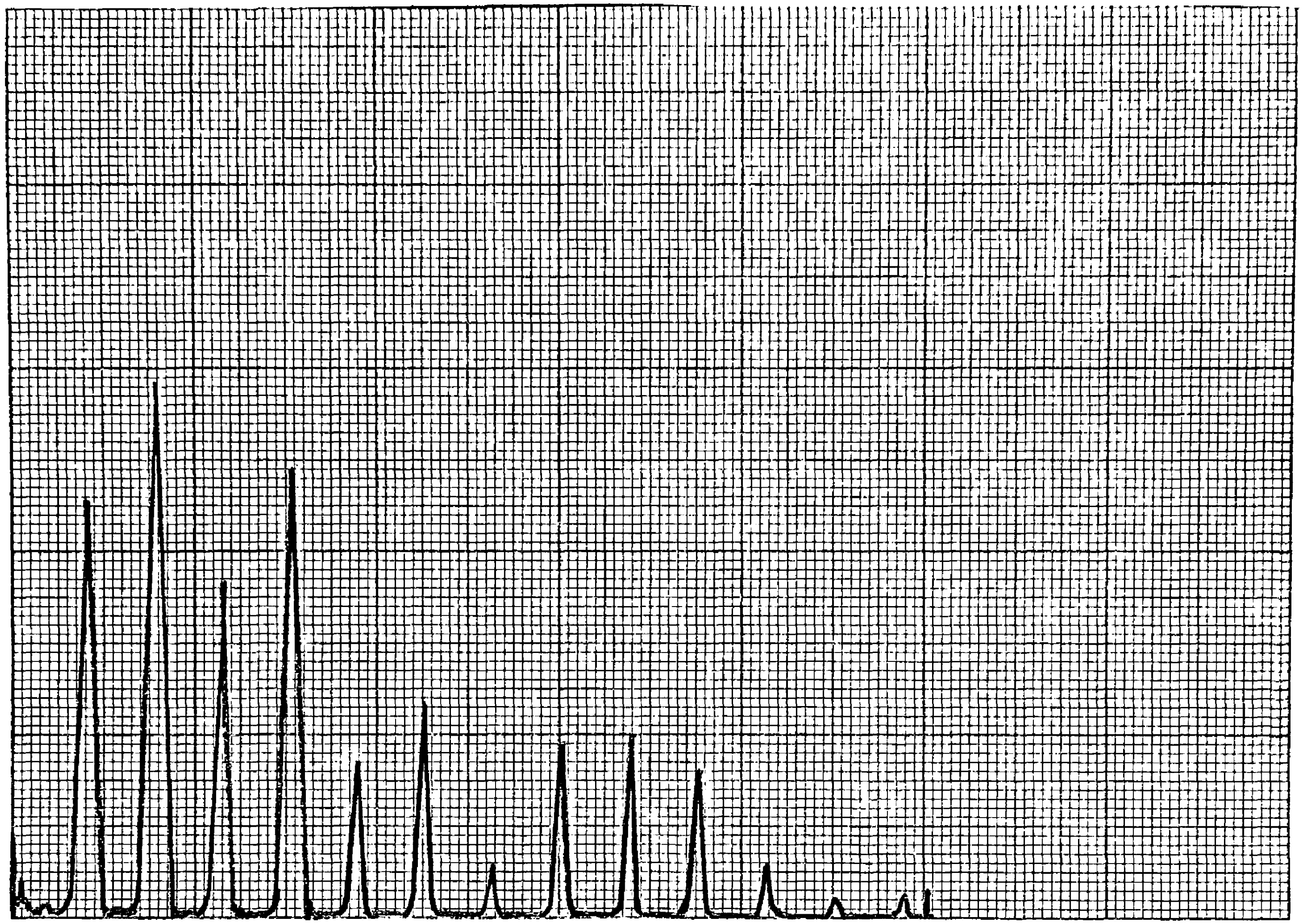
Spectrum Analysis Graph: Group II, Subject Number 4, Pitch b^b.



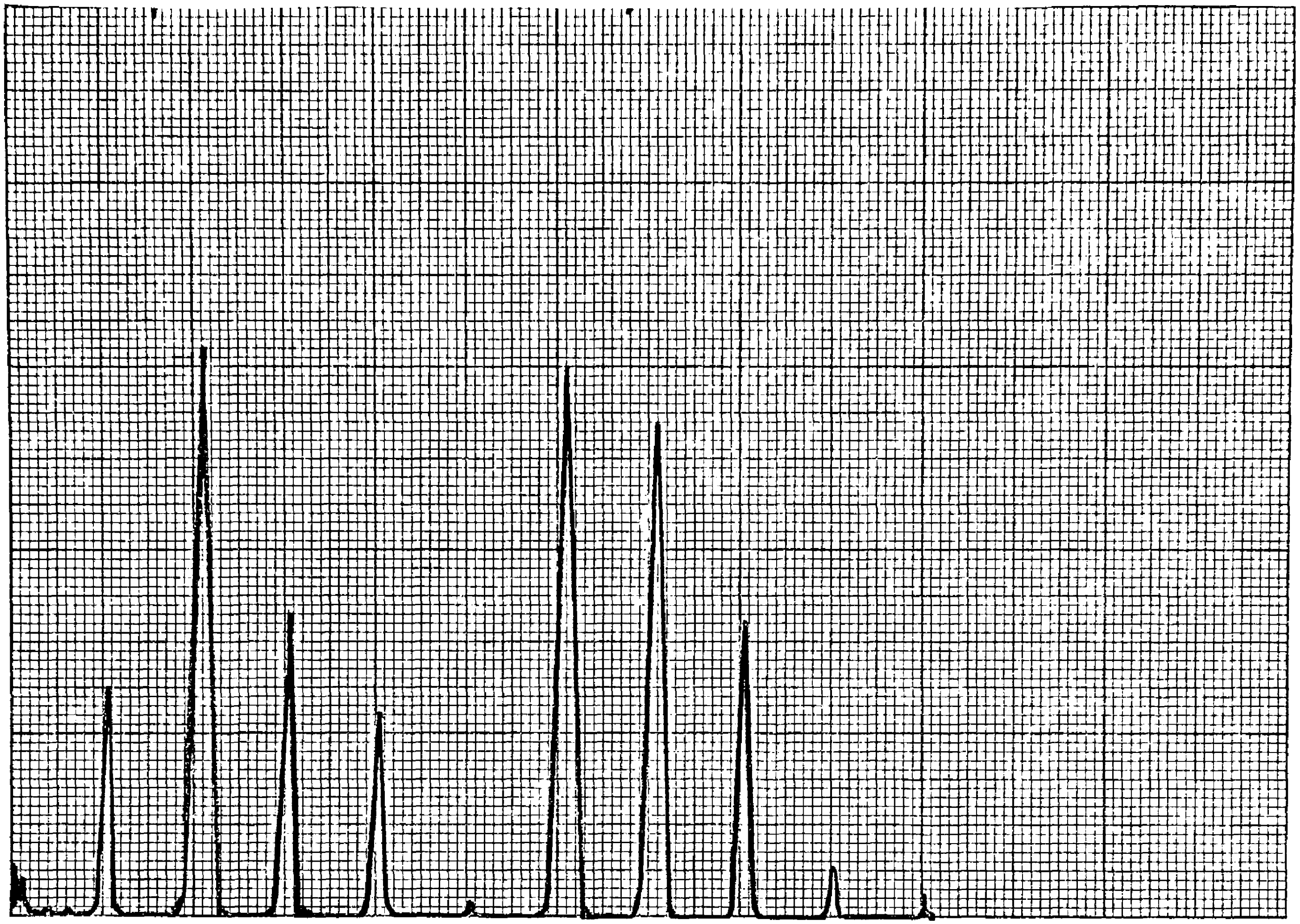
Spectrum Analysis Graph: Group II, Subject Number 4, Pitch e^b.



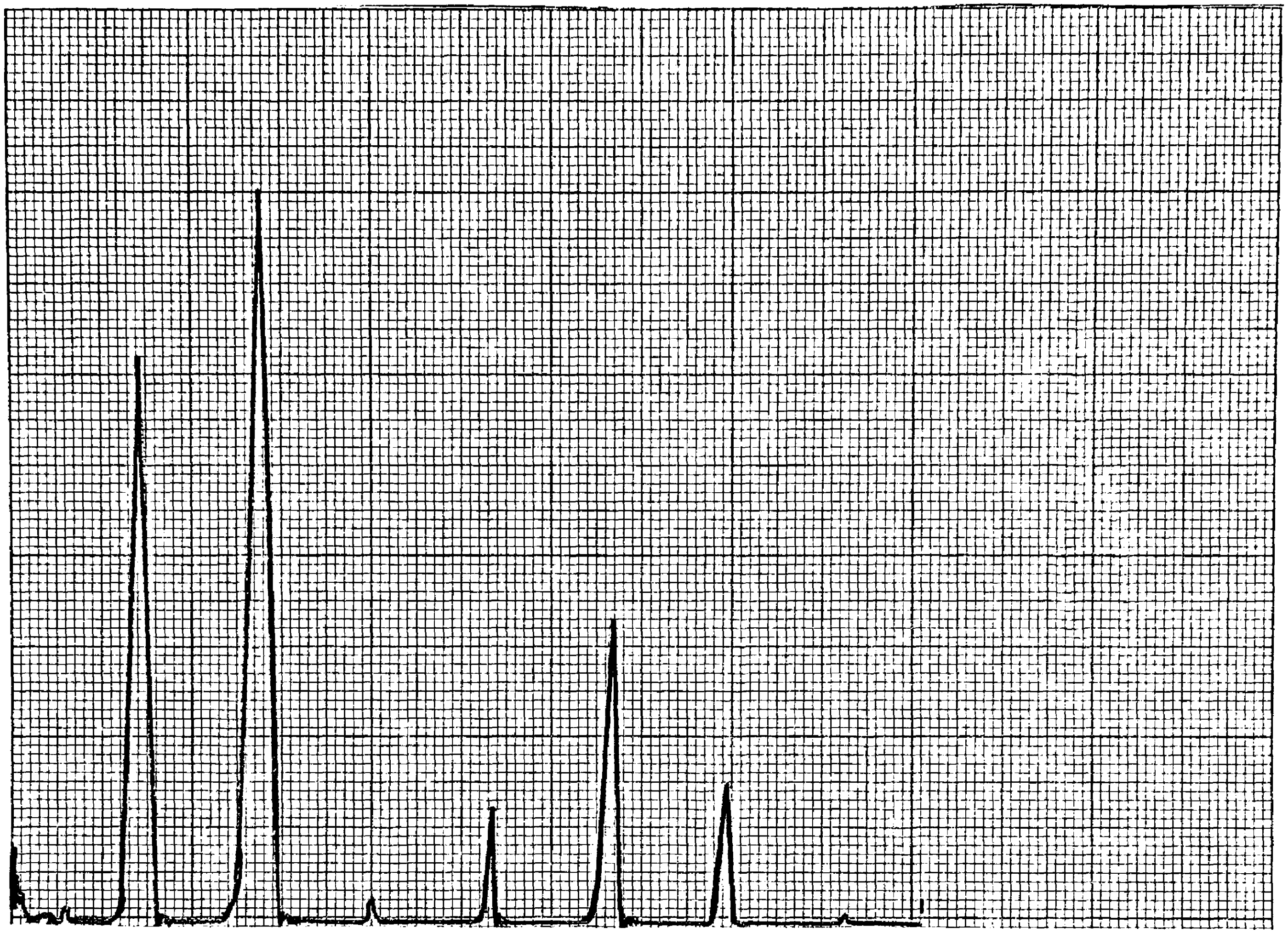
Spectrum Analysis Graph: Group II, Subject Number 5, Pitch d.



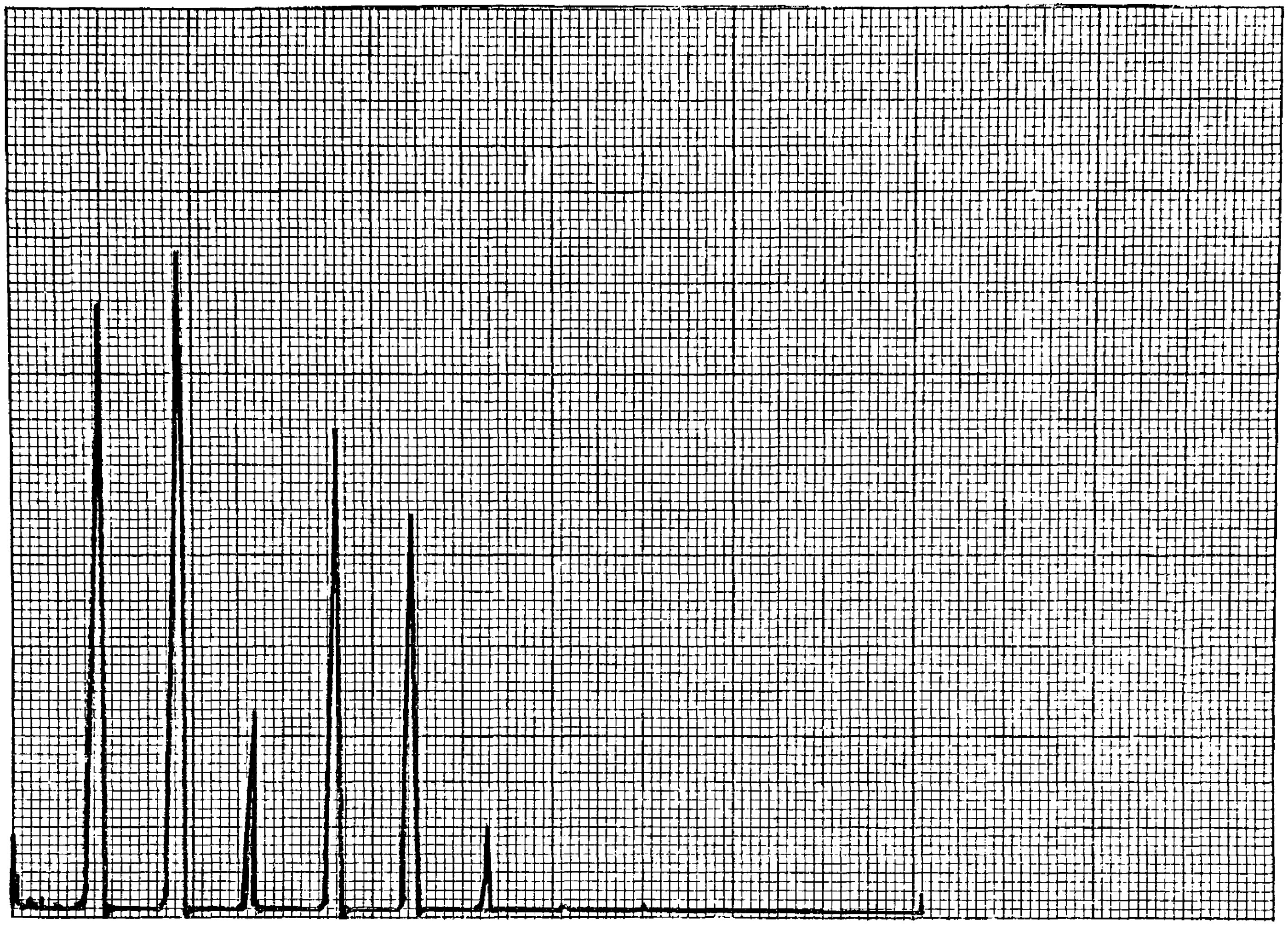
Spectrum Analysis Graph: Group II, Subject Number 5, Pitch g.



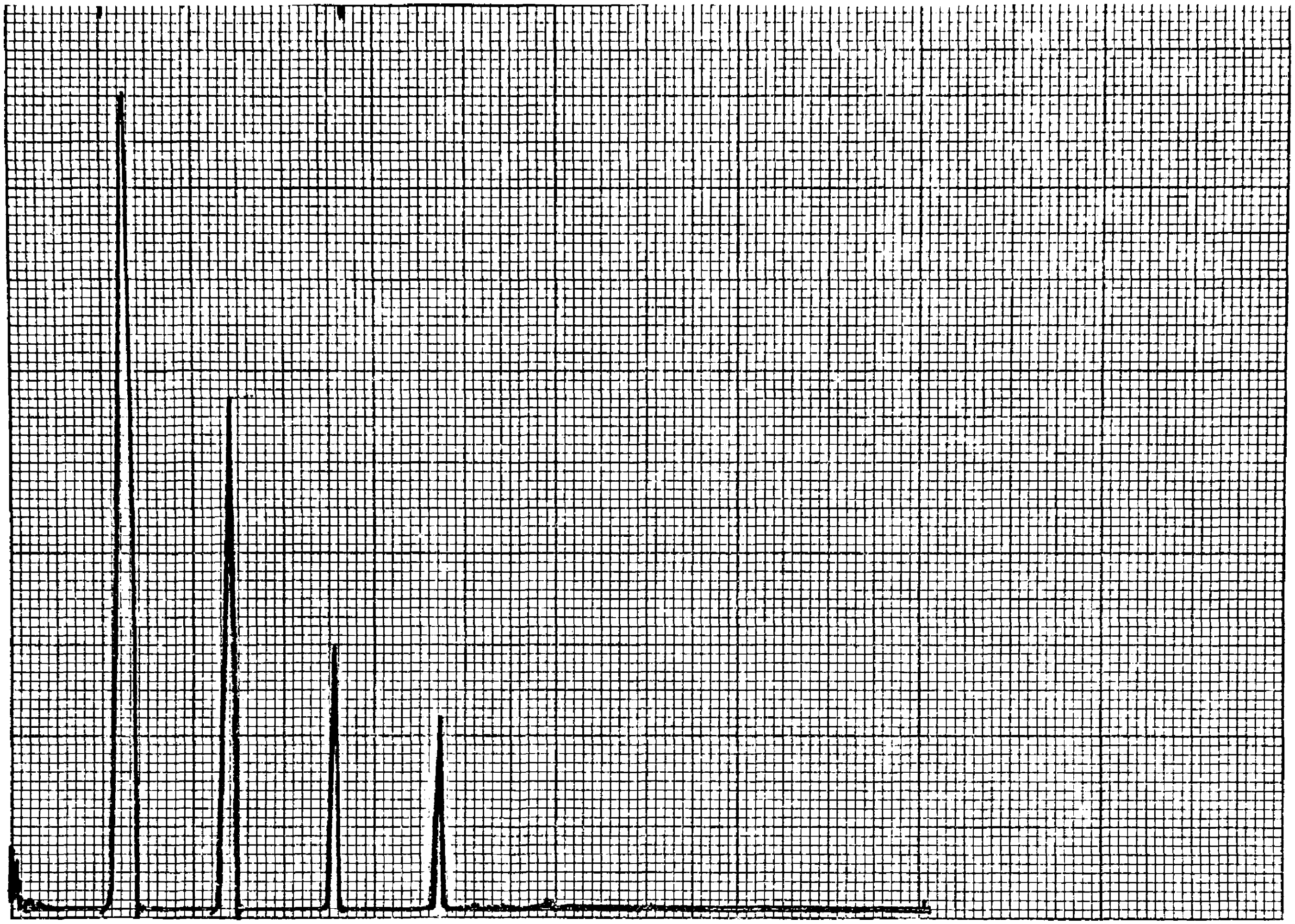
Spectrum Analysis Graph: Group II, Subject Number 5, Pitch c.



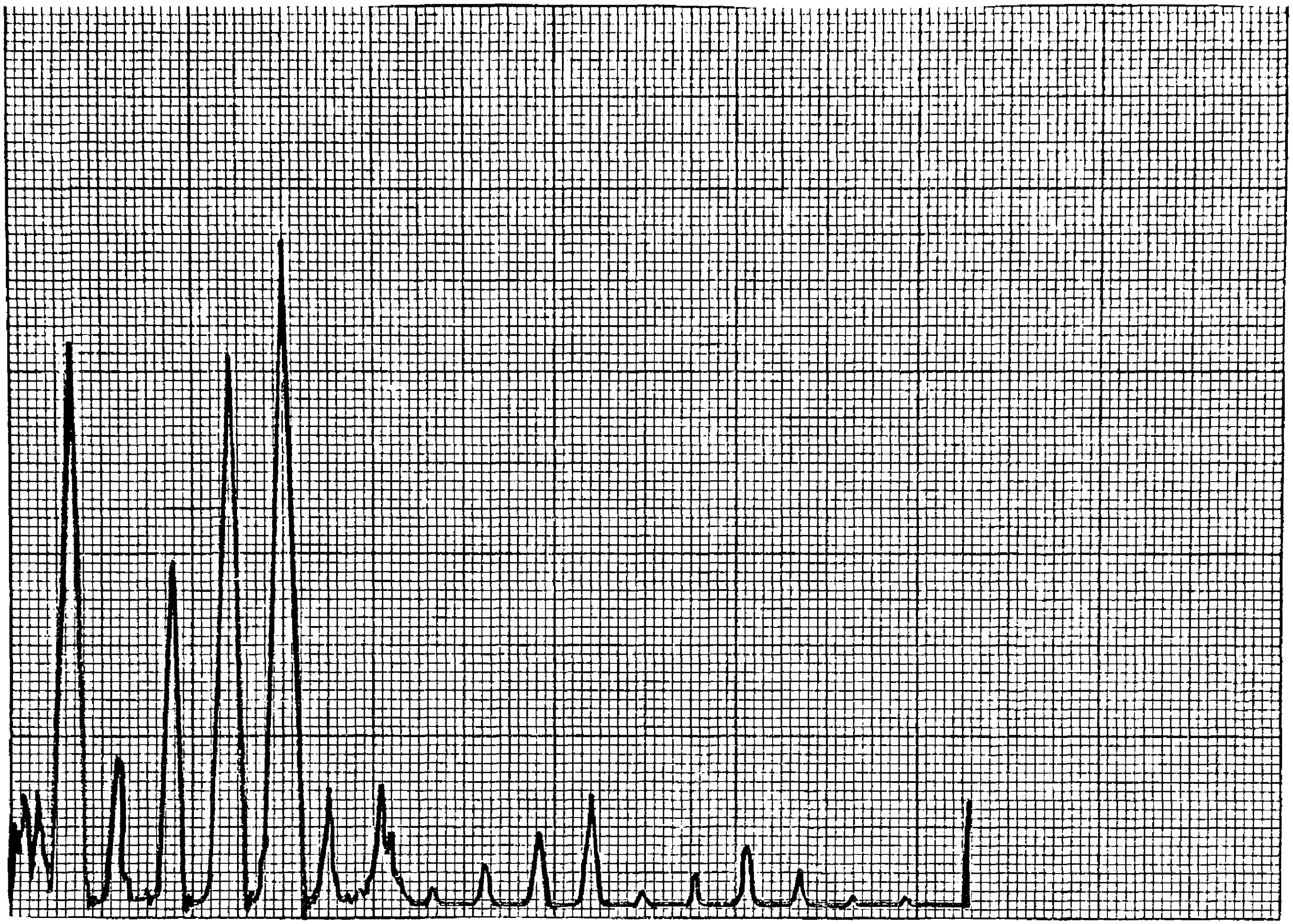
Spectrum Analysis Graph: Group II, Subject Number 5, Pitch f.



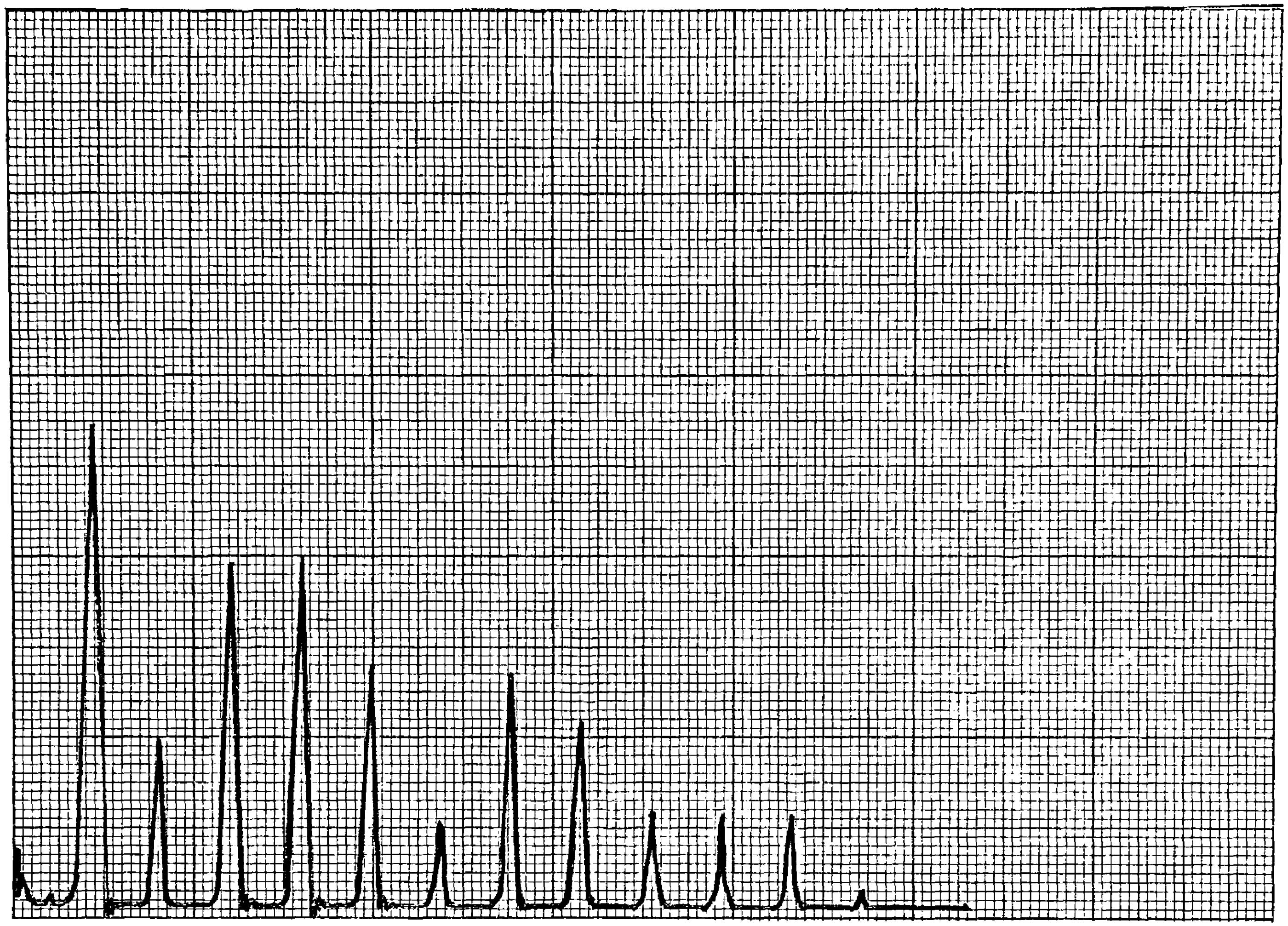
Spectrum Analysis Graph: Group II, Subject Number 5, Pitch b^b.



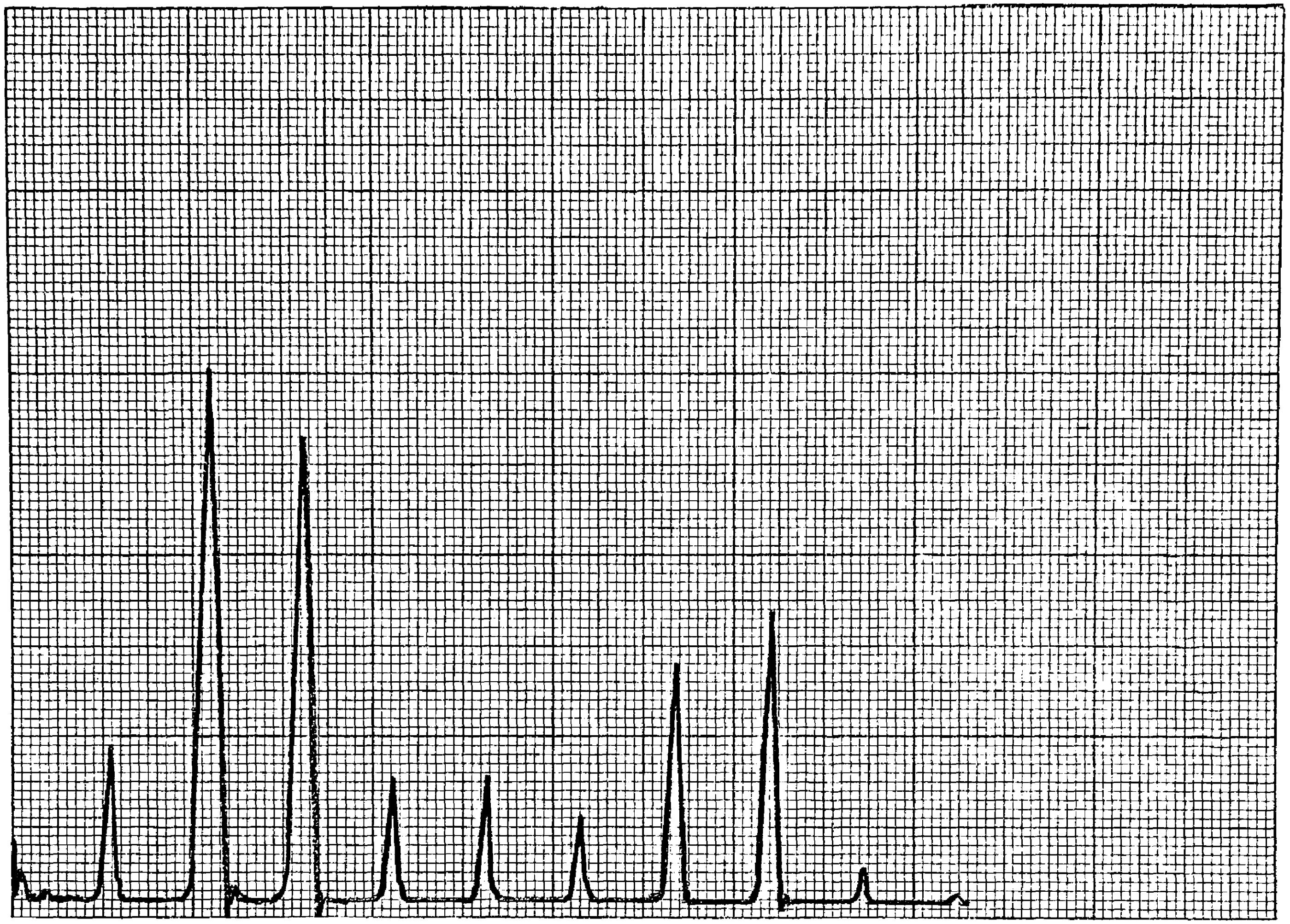
Spectrum Analysis Graph: Group II, Subject Number 5, Pitch e^b.



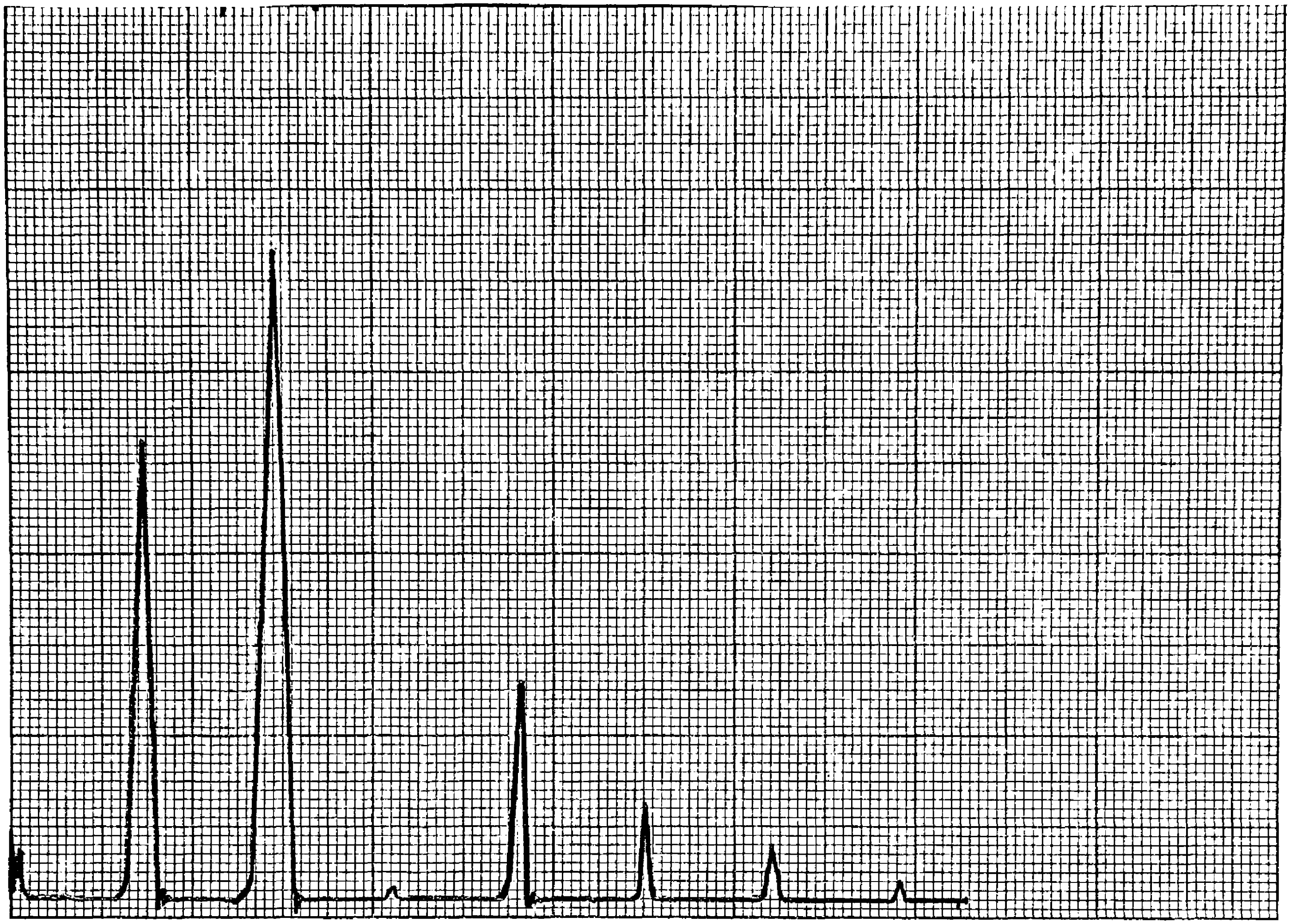
Spectrum Analysis Graph: Group II, Subject Number 6, Pitch d.



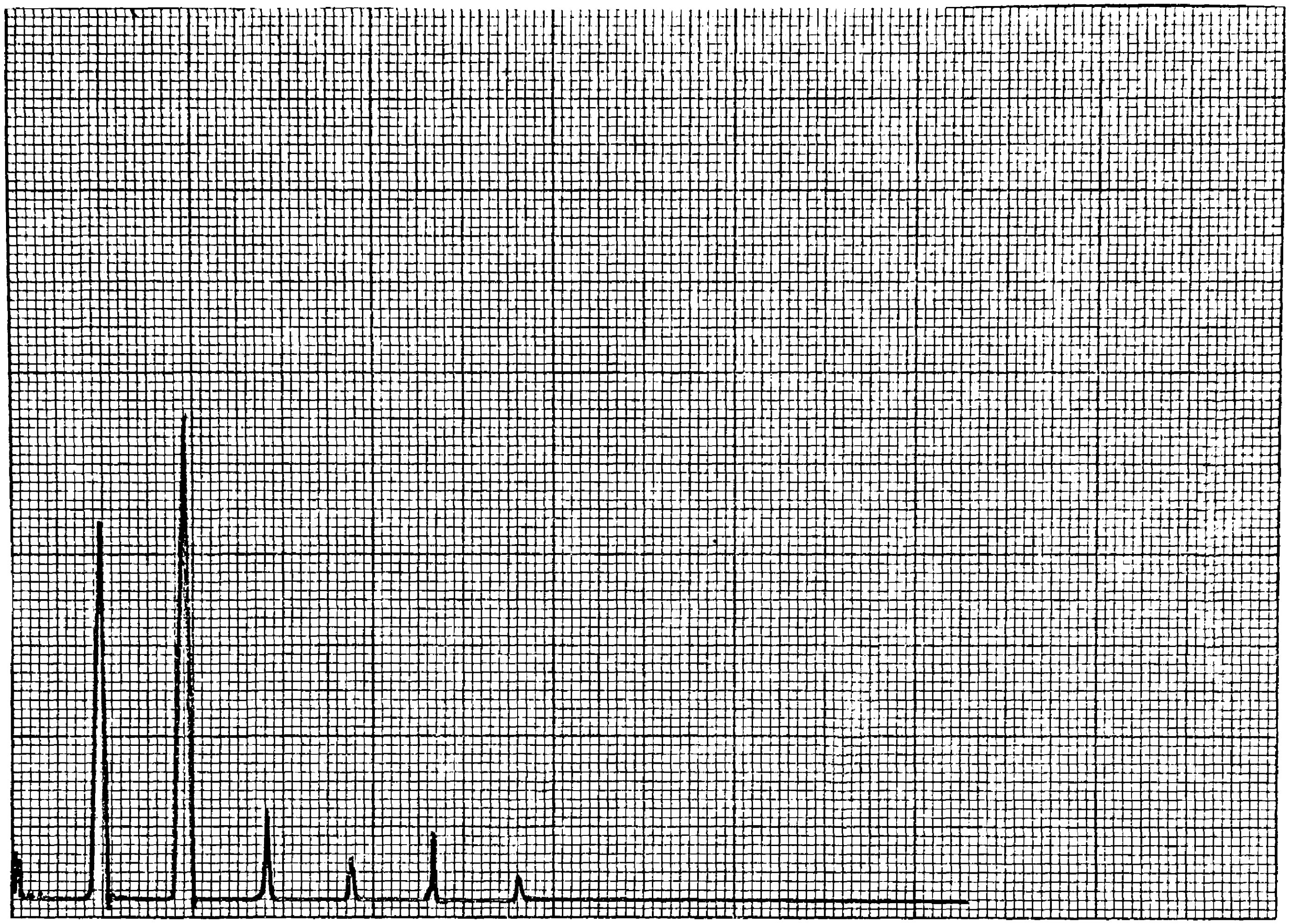
Spectrum Analysis Graph: Group II, Subject Number 6, Pitch g.



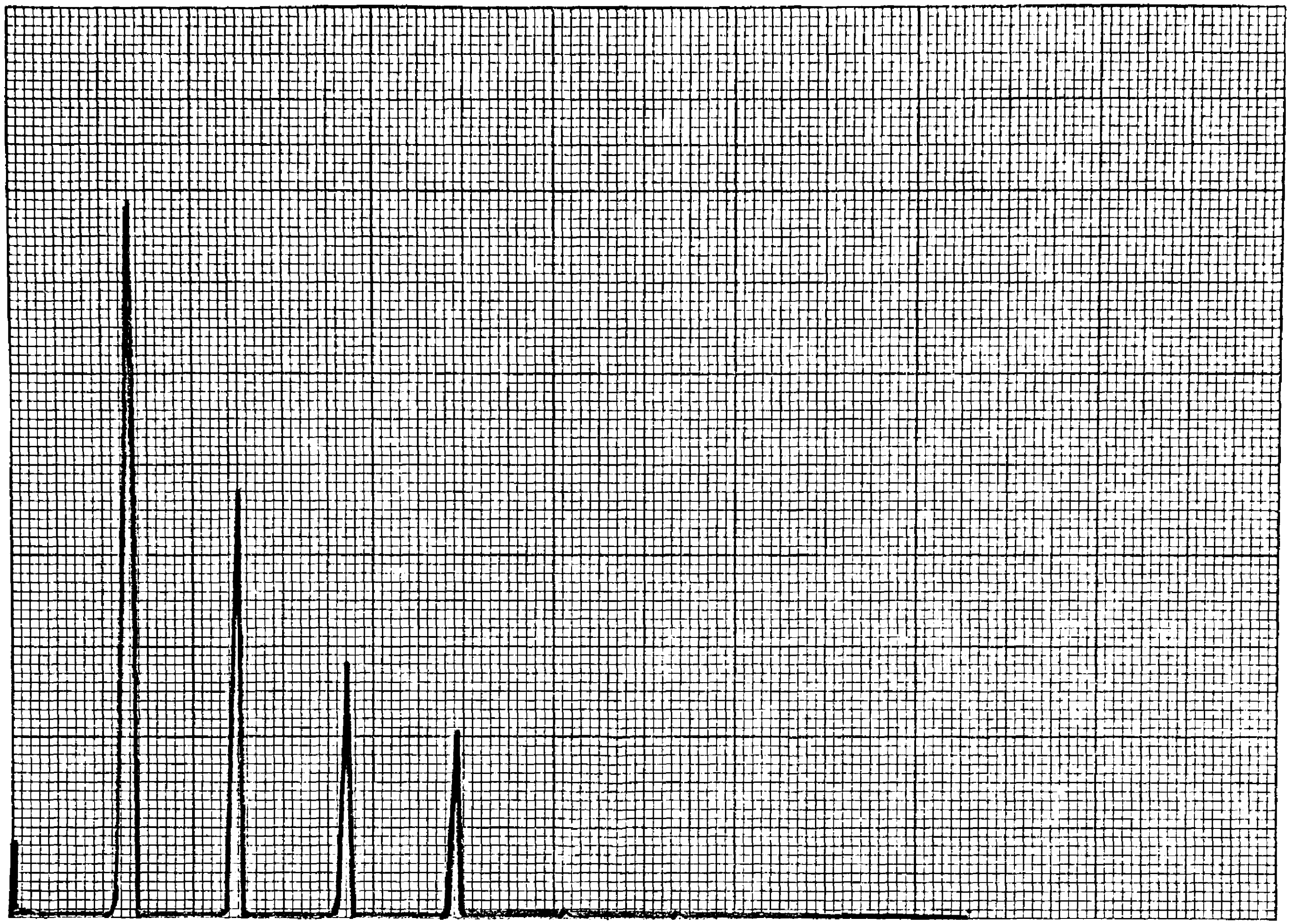
Spectrum Analysis Graph: Group II, Subject Number 6, Pitch c.



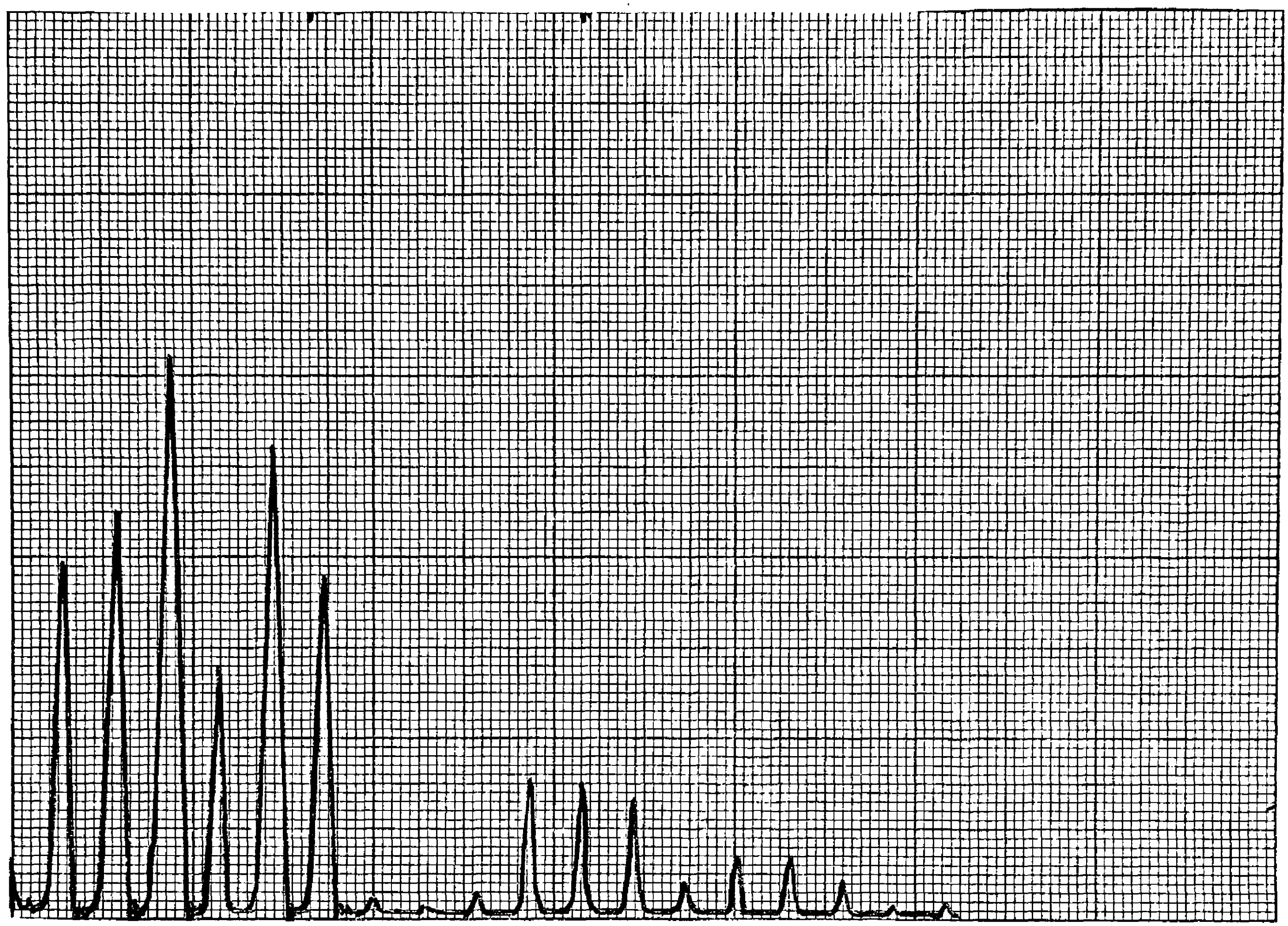
Spectrum Analysis Graph: Group II, Subject Number 6, Pitch f.



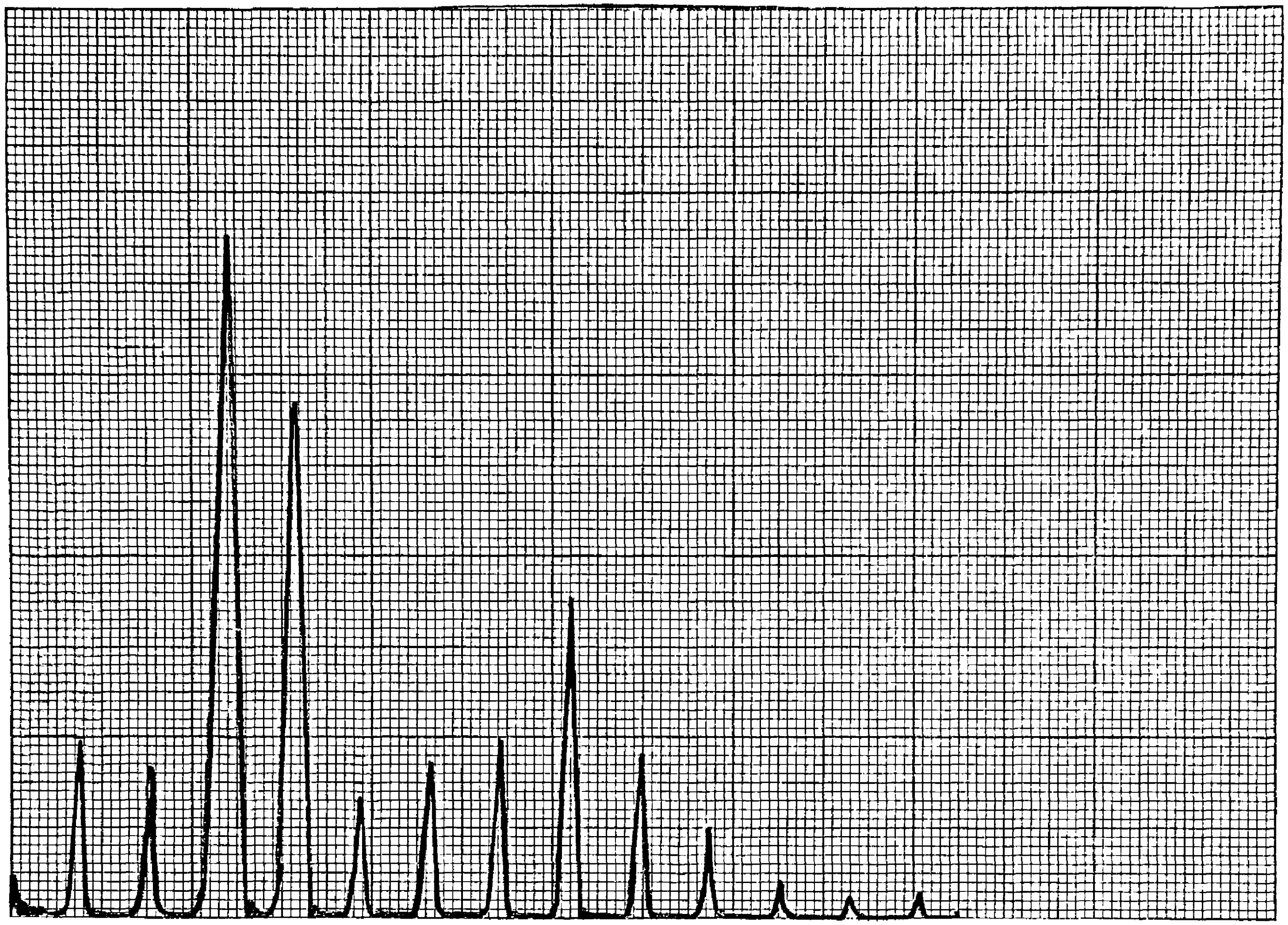
Spectrum Analysis Graph: Group II, Subject Number 6, Pitch b[b].



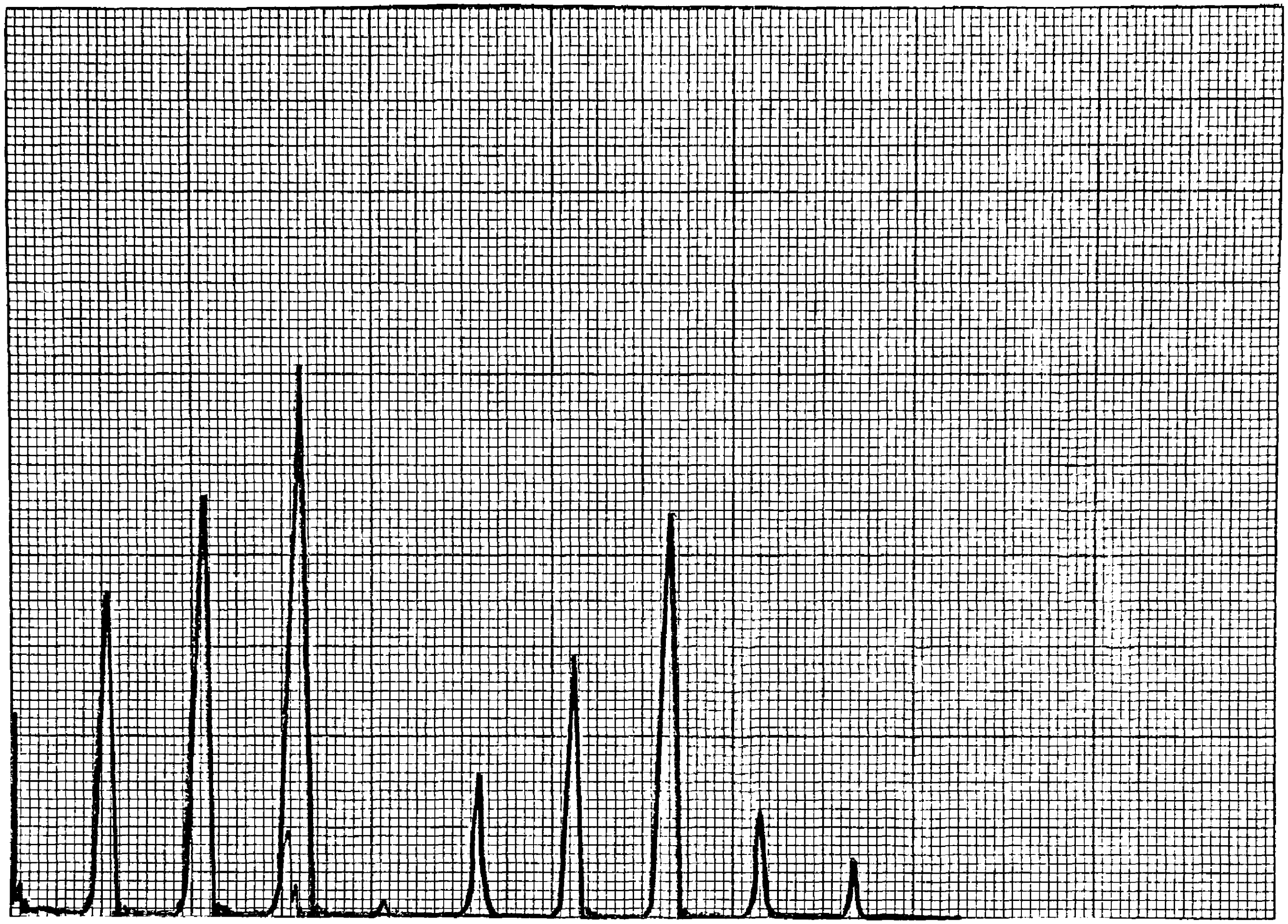
Spectrum Analysis Graph: Group II, Subject Number 6, Pitch e^{b}.



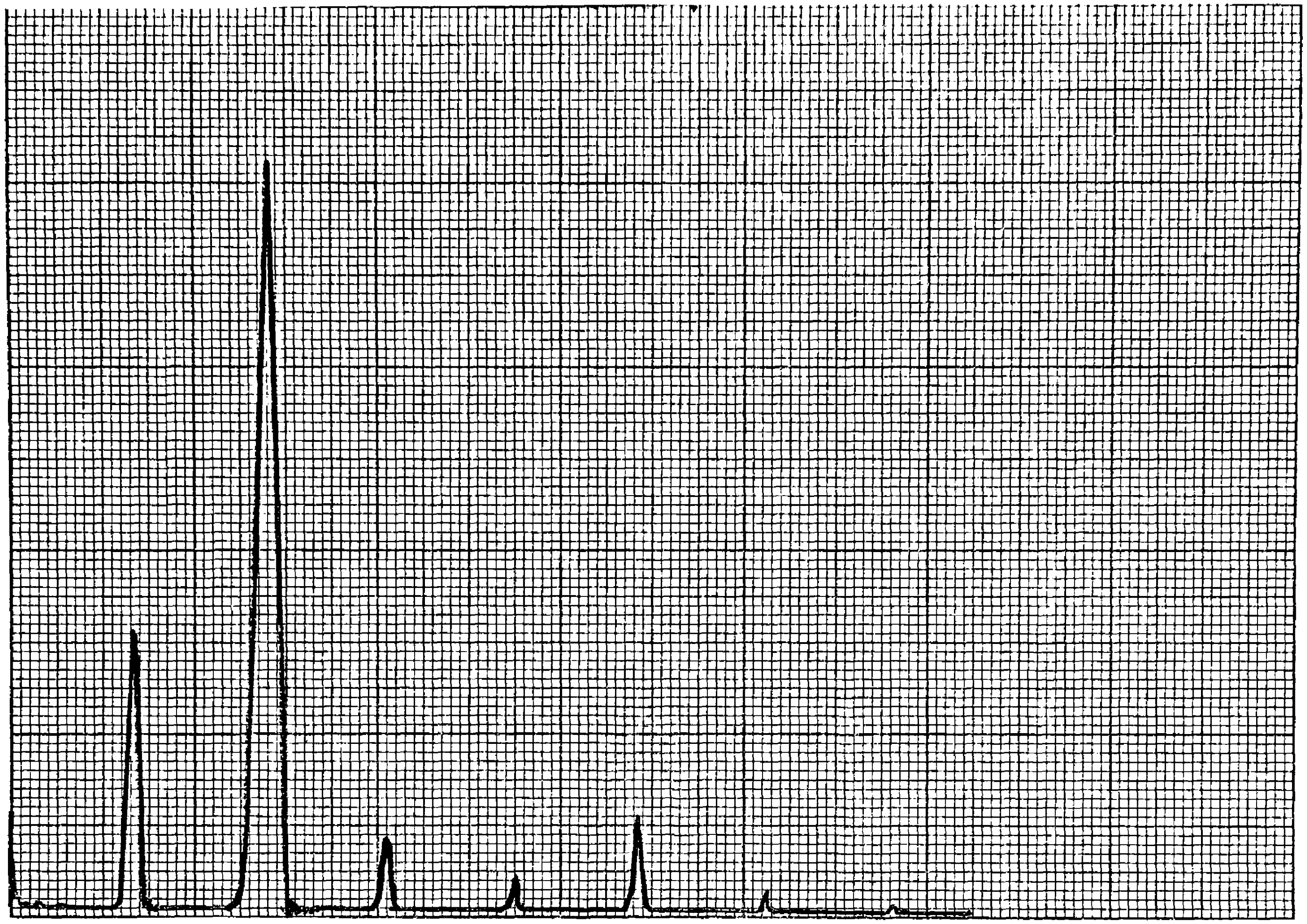
Spectrum Analysis Graph: Group II, Subject Number 16, Pitch d.



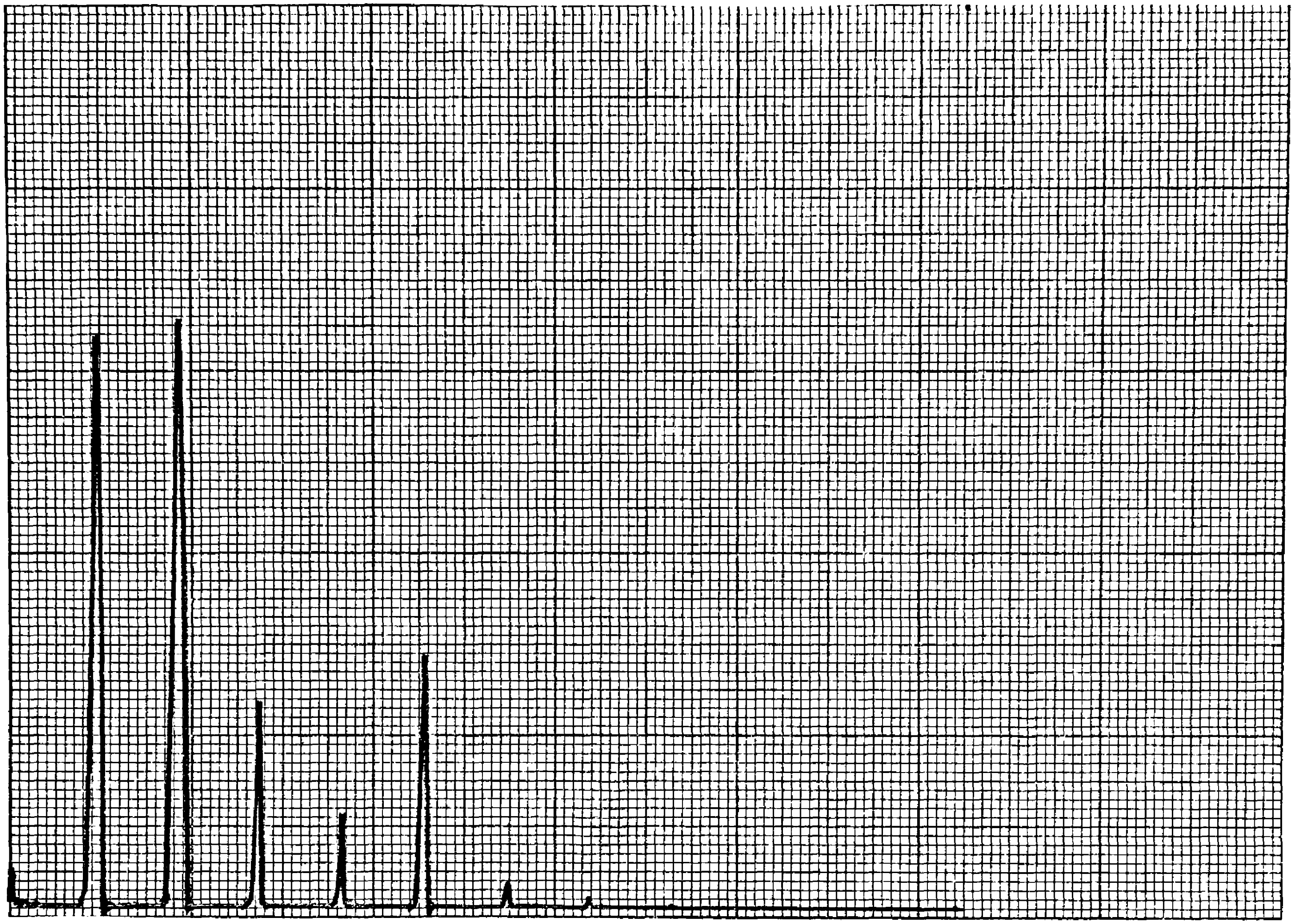
Spectrum Analysis Graph: Group II, Subject Number 16, Pitch g.



Spectrum Analysis Graph: Group II, Subject Number 16, Pitch c.

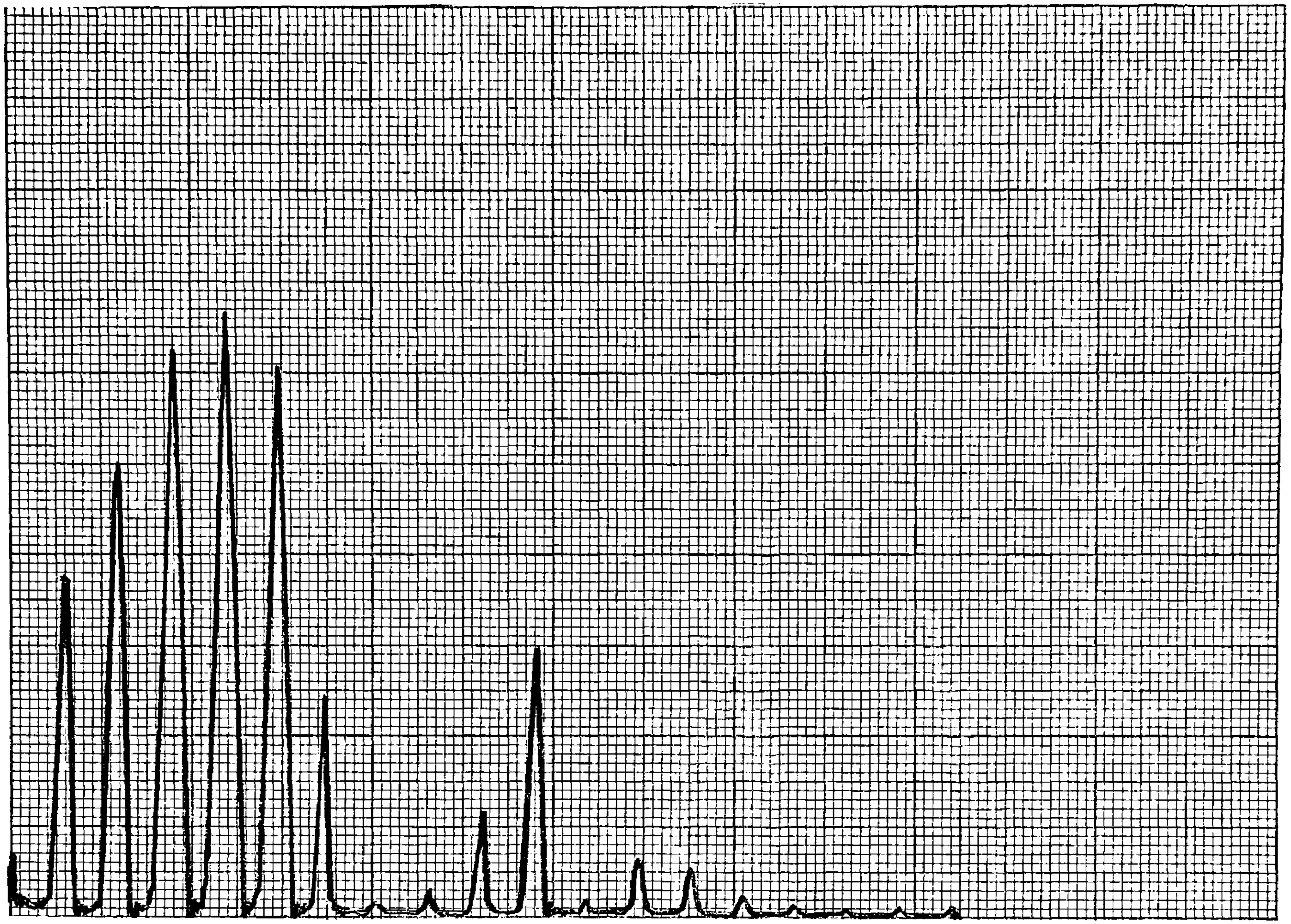


Spectrum Analysis Graph: Group II, Subject Number 16, Pitch f.

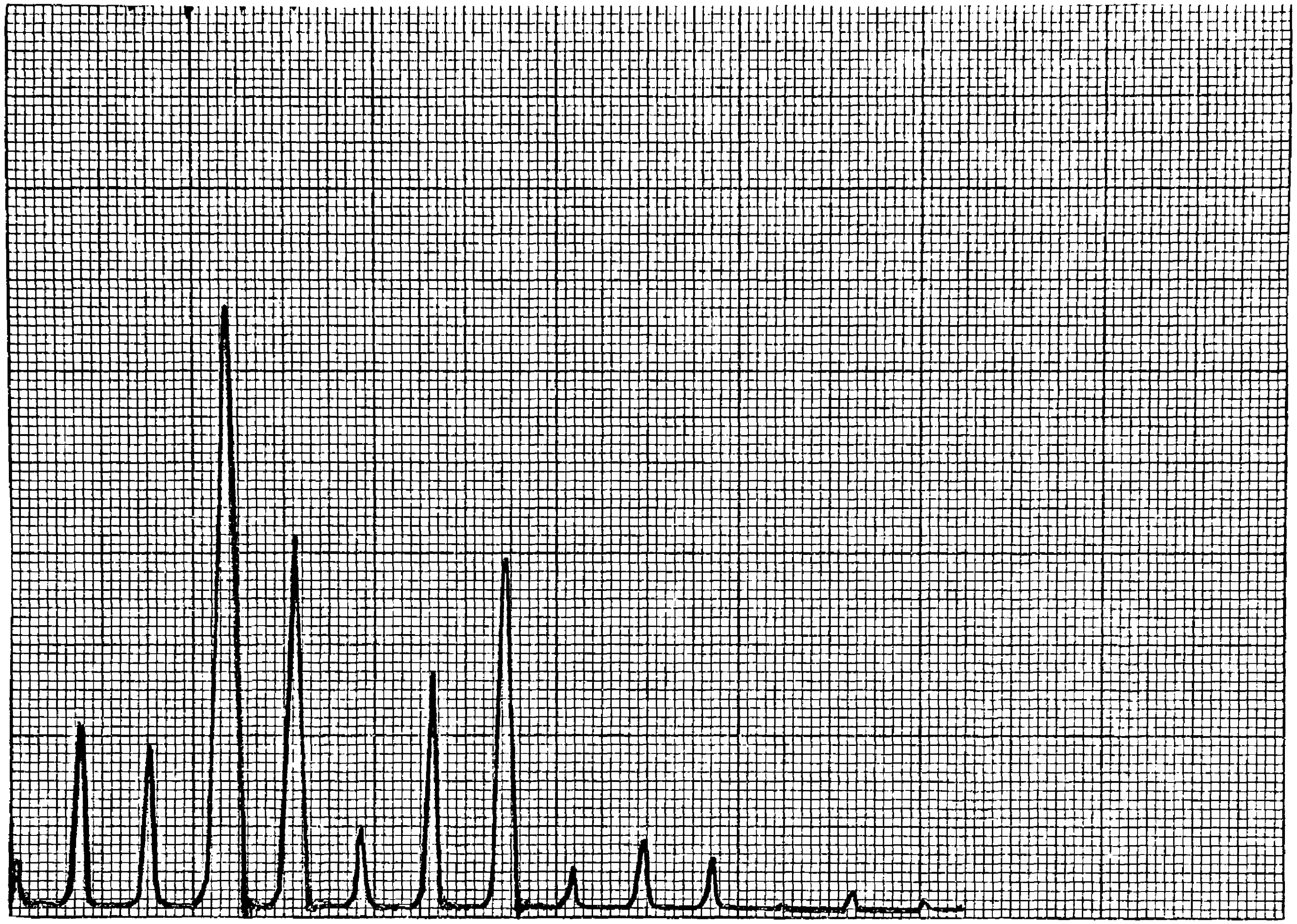


Spectrum Analysis Graph: Group II, Subject Number 16, Pitch b^{b}.

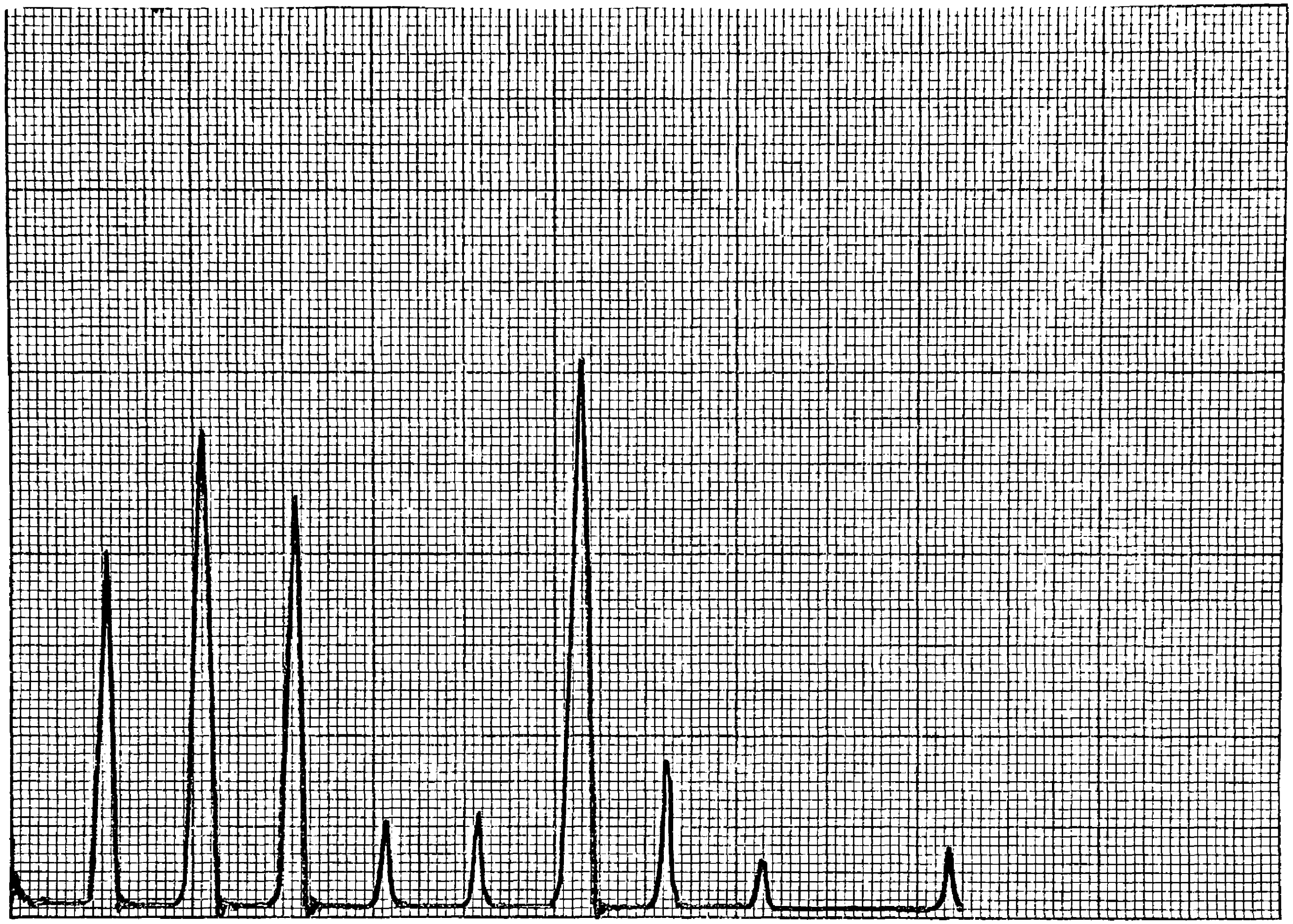
Spectrum Analysis Graph: Group II, Subject Number 16, Pitch e^b.



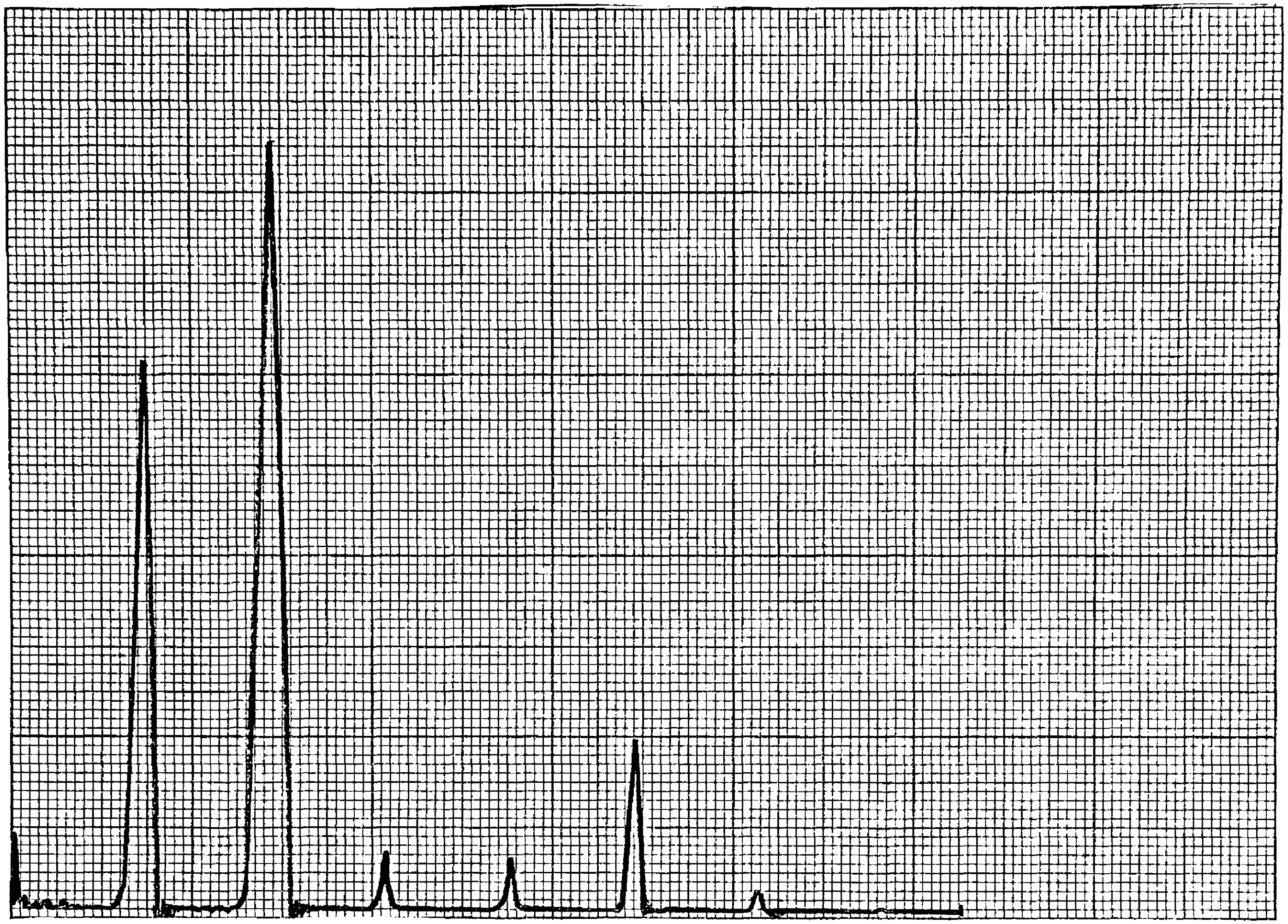
Spectrum Analysis Graph: Group II, Subject Number 17, Pitch d.



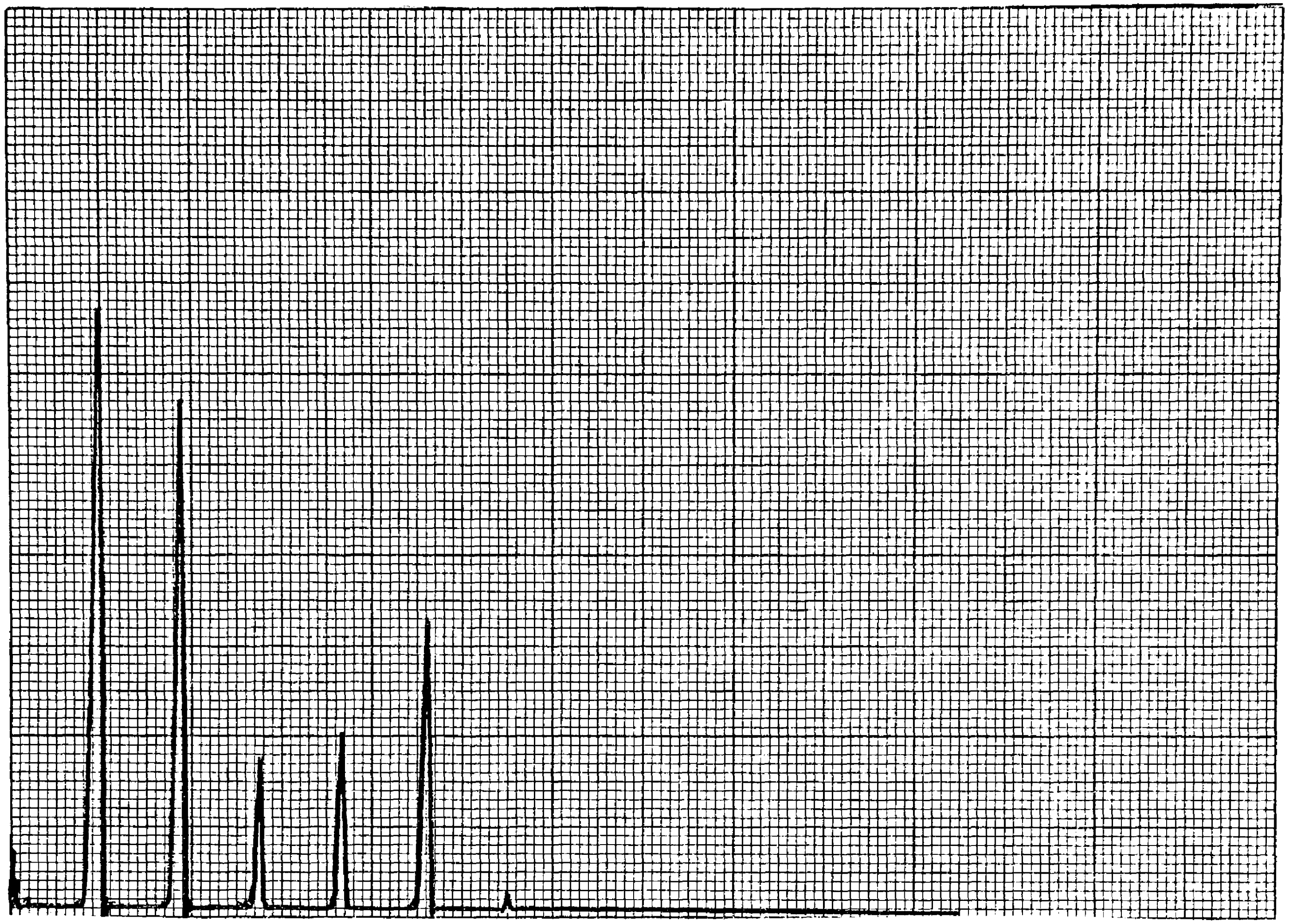
Spectrum Analysis Graph: Group II, Subject Number 17, Pitch g.



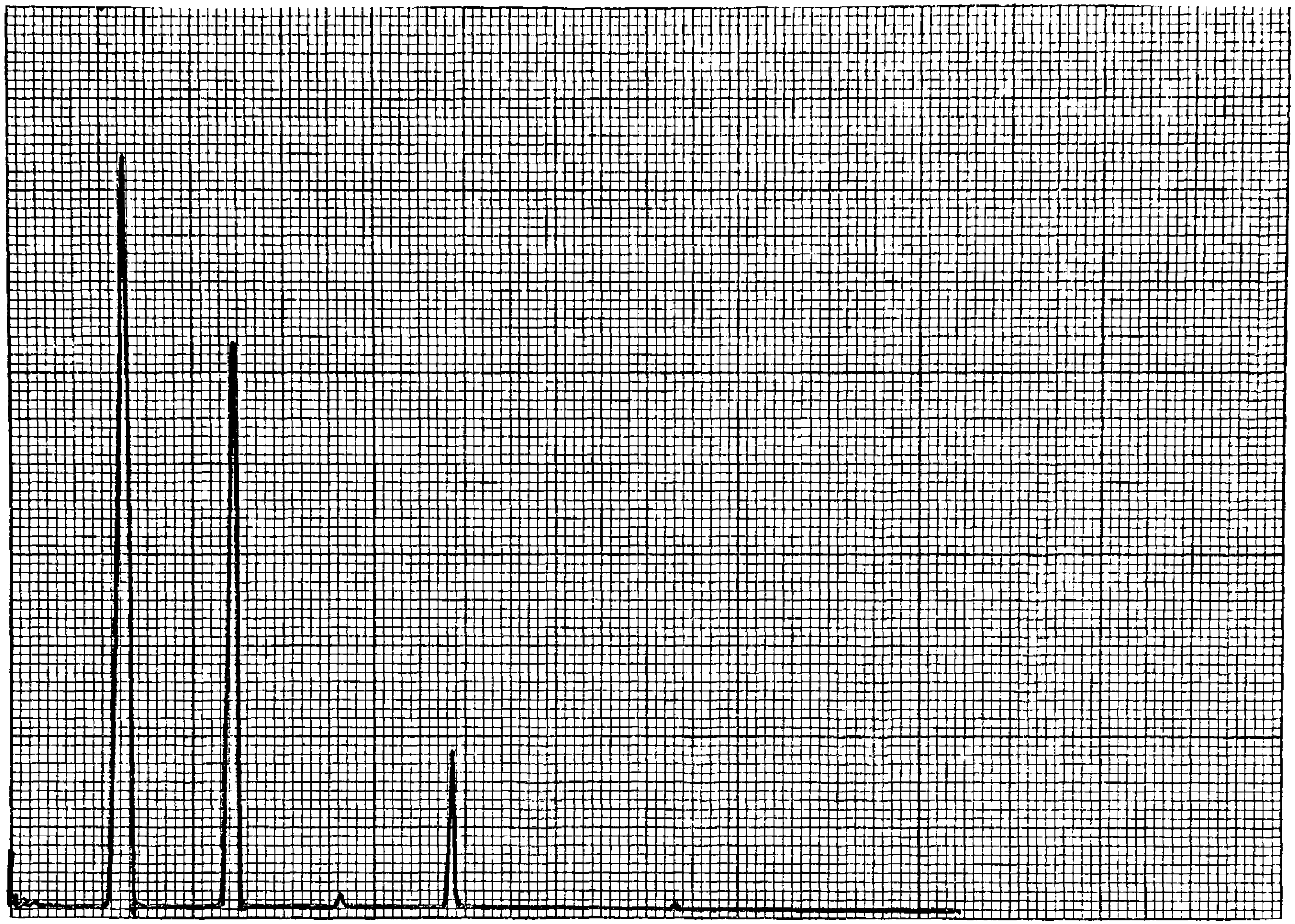
Spectrum Analysis Graph: Group II, Subject Number 17, Pitch c.



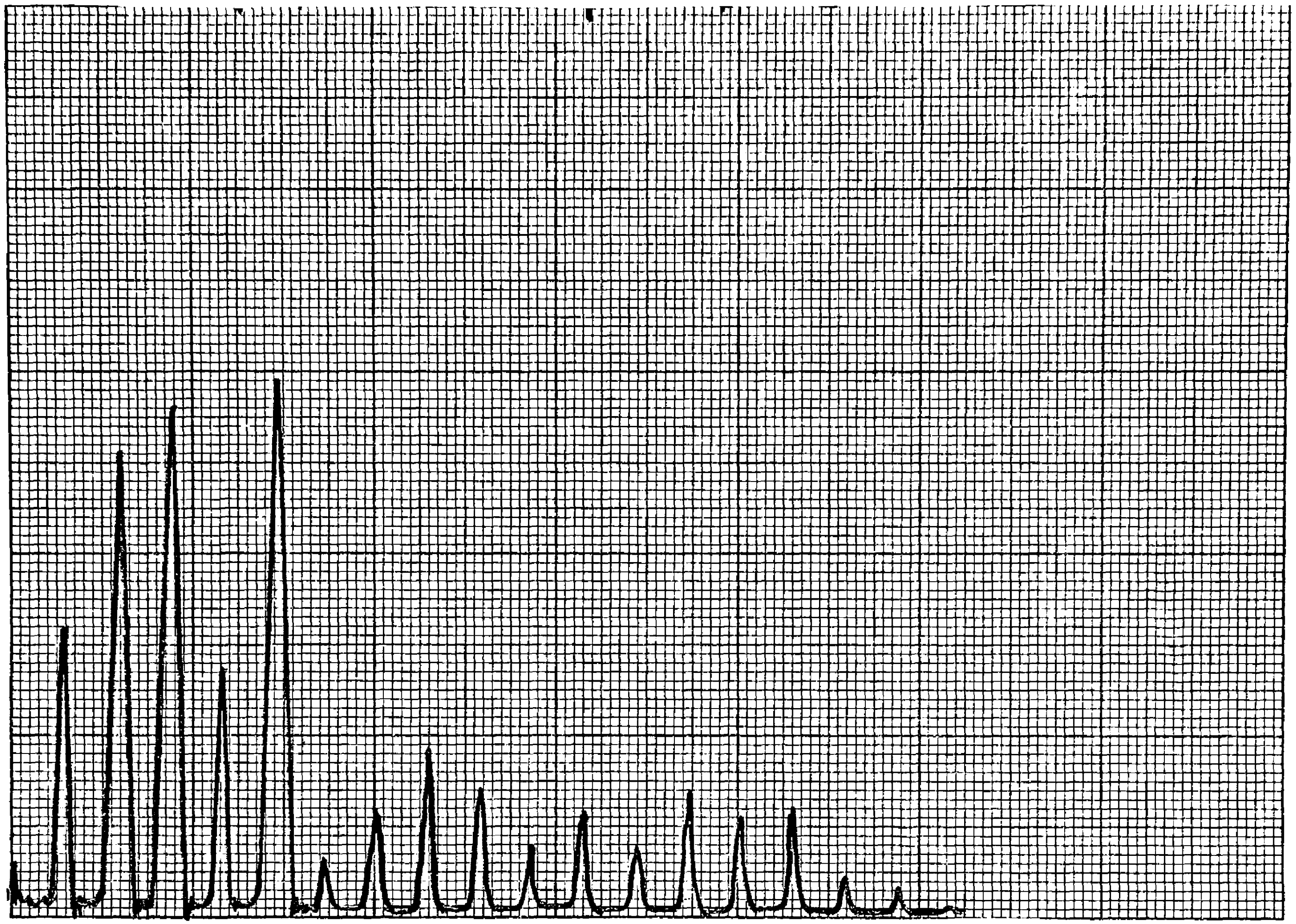
Spectrum Analysis Graph: Group II, Subject Number 17, Pitch f.



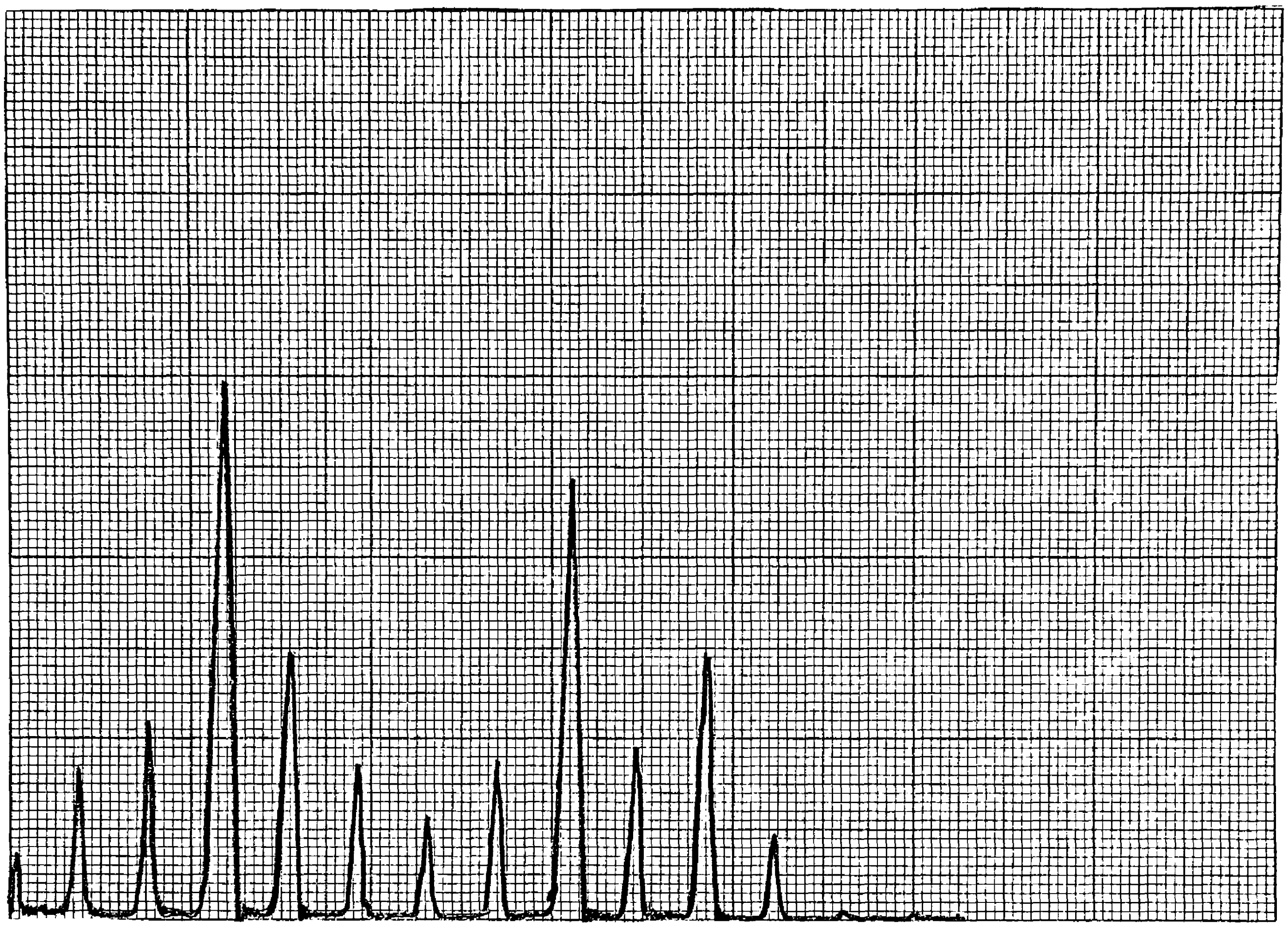
Spectrum Analysis Graph: Group II, Subject Number 17, Pitch b^b.



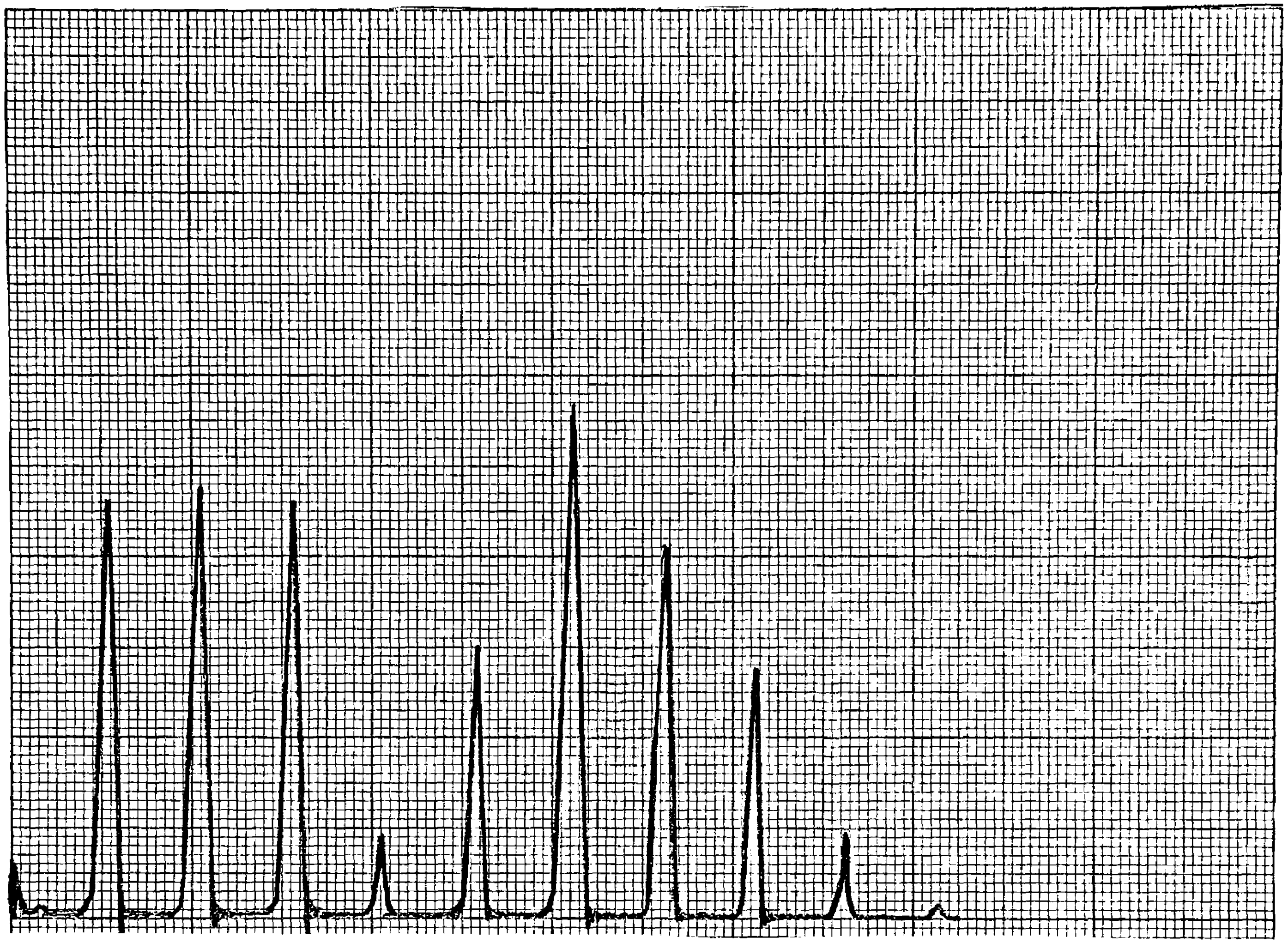
Spectrum Analysis Graph: Group II, Subject Number 17, Pitch e^b.



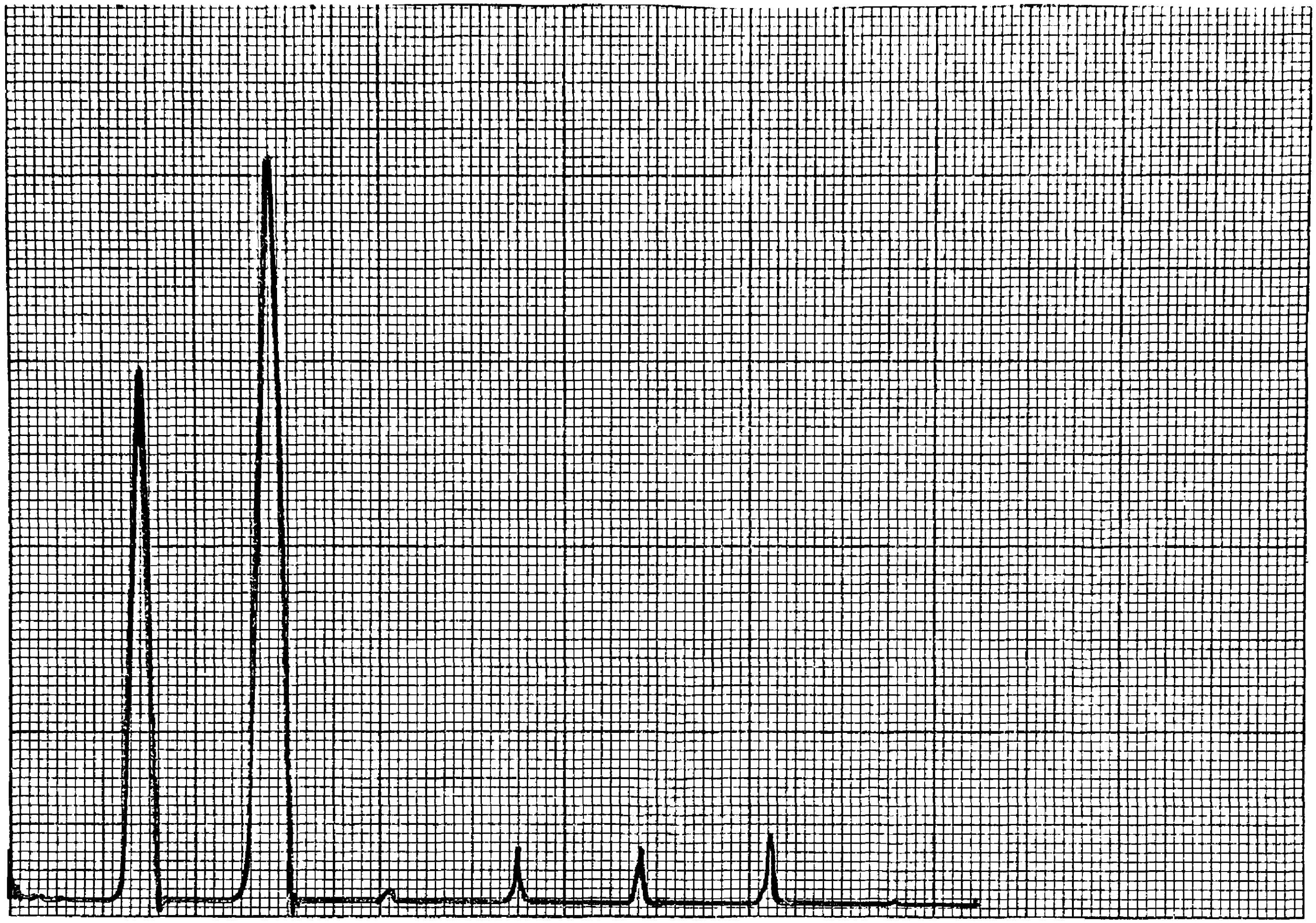
Spectrum Analysis Graph: Group II, Subject Number 18, Pitch d.



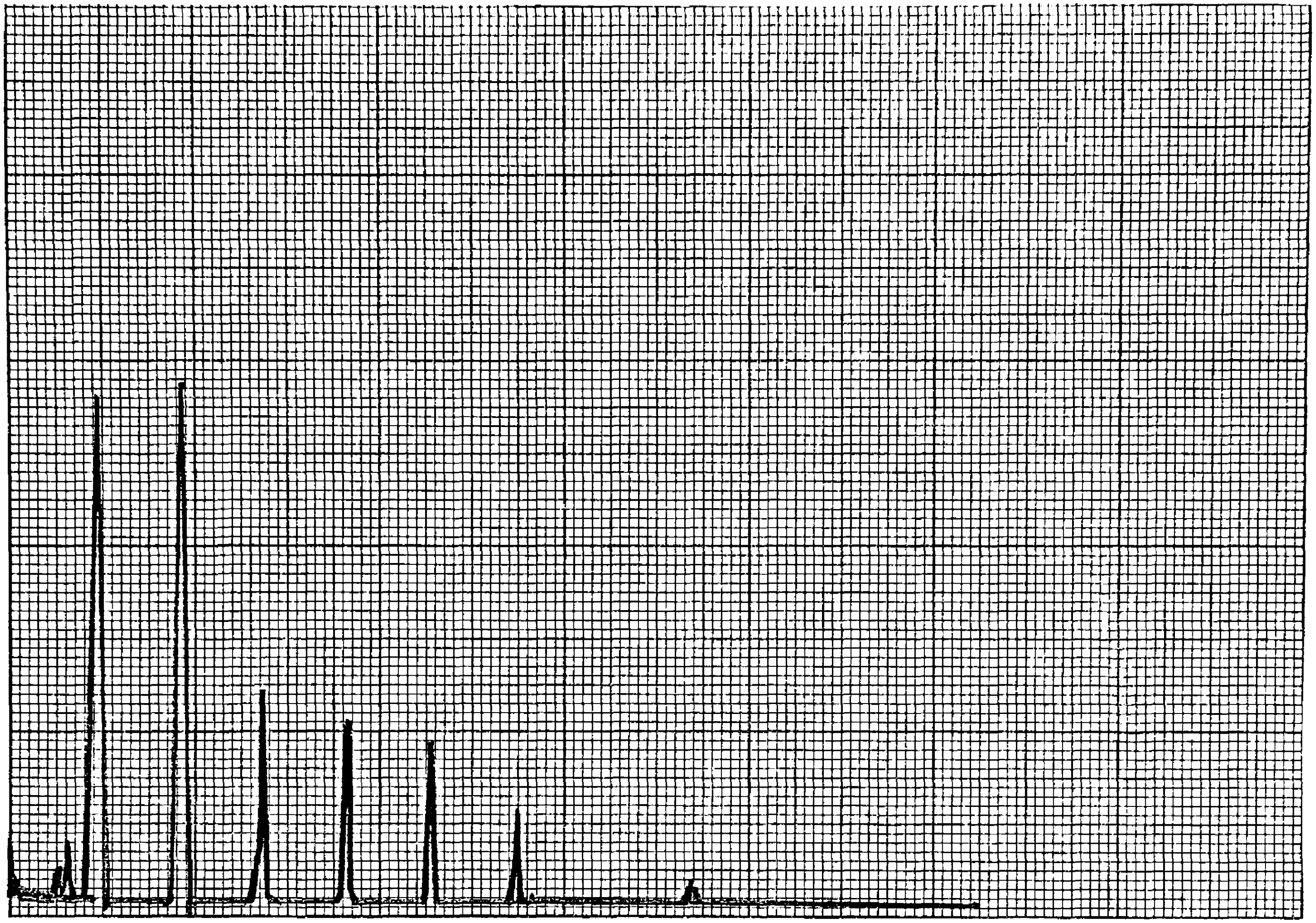
Spectrum Analysis Graph: Group II, Subject Number 18, Pitch g.



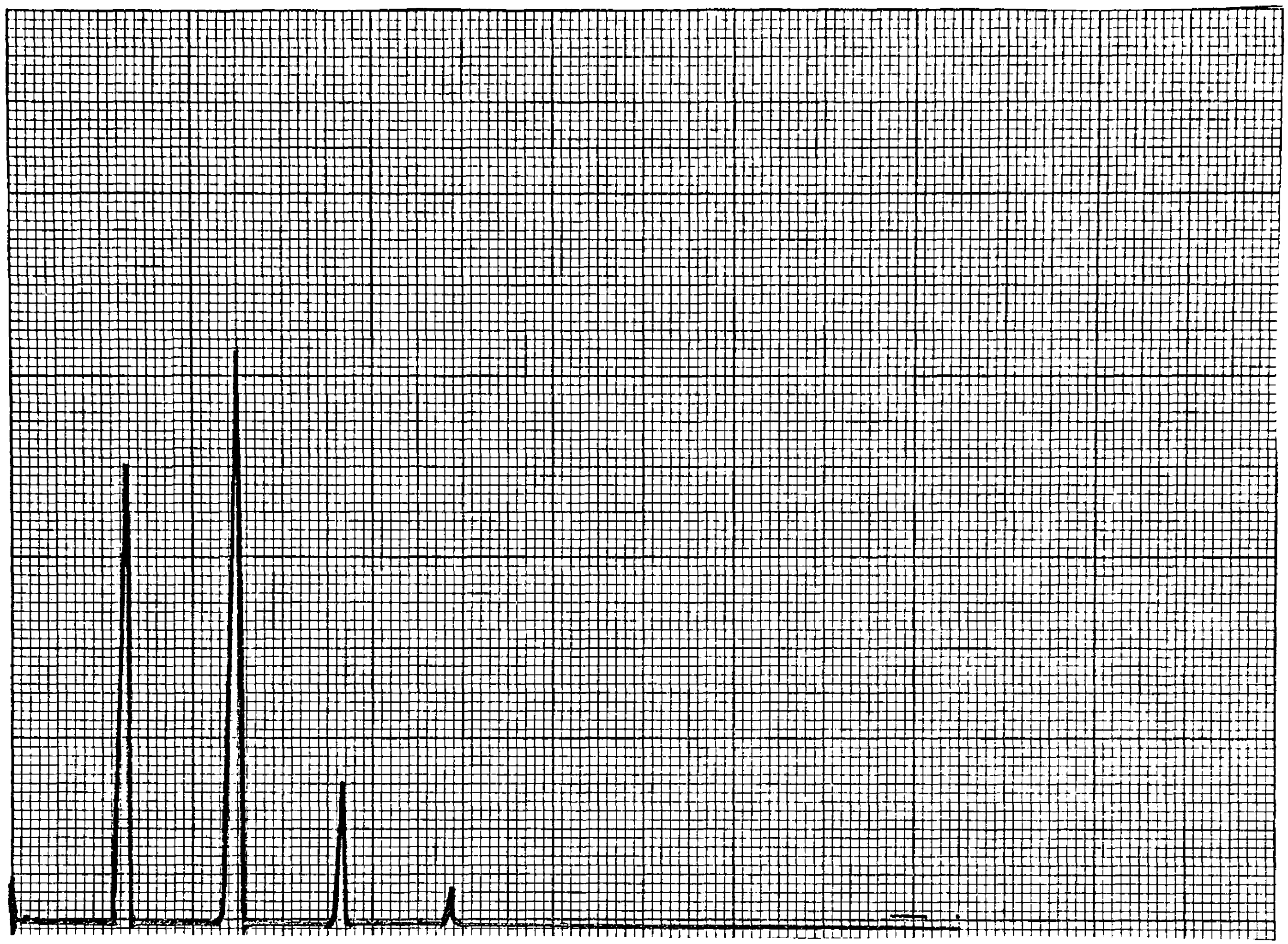
Spectrum Analysis Graph: Group II, Subject Number 18, Pitch c.



Spectrum Analysis Graph: Group II, Subject Number 18, Pitch f.

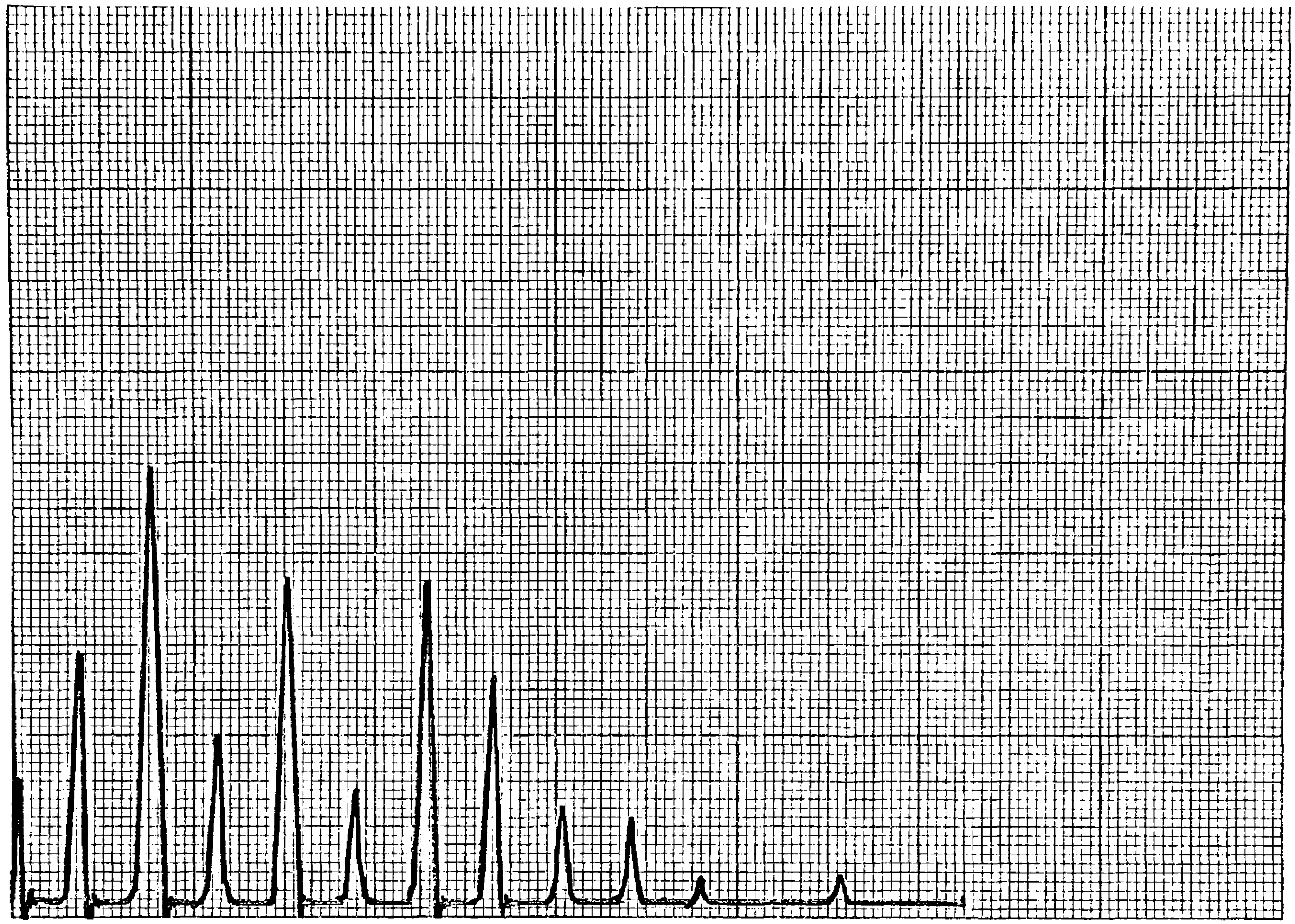


Spectrum Analysis Graph: Group II, Subject Number 18, Pitch b^{b}.

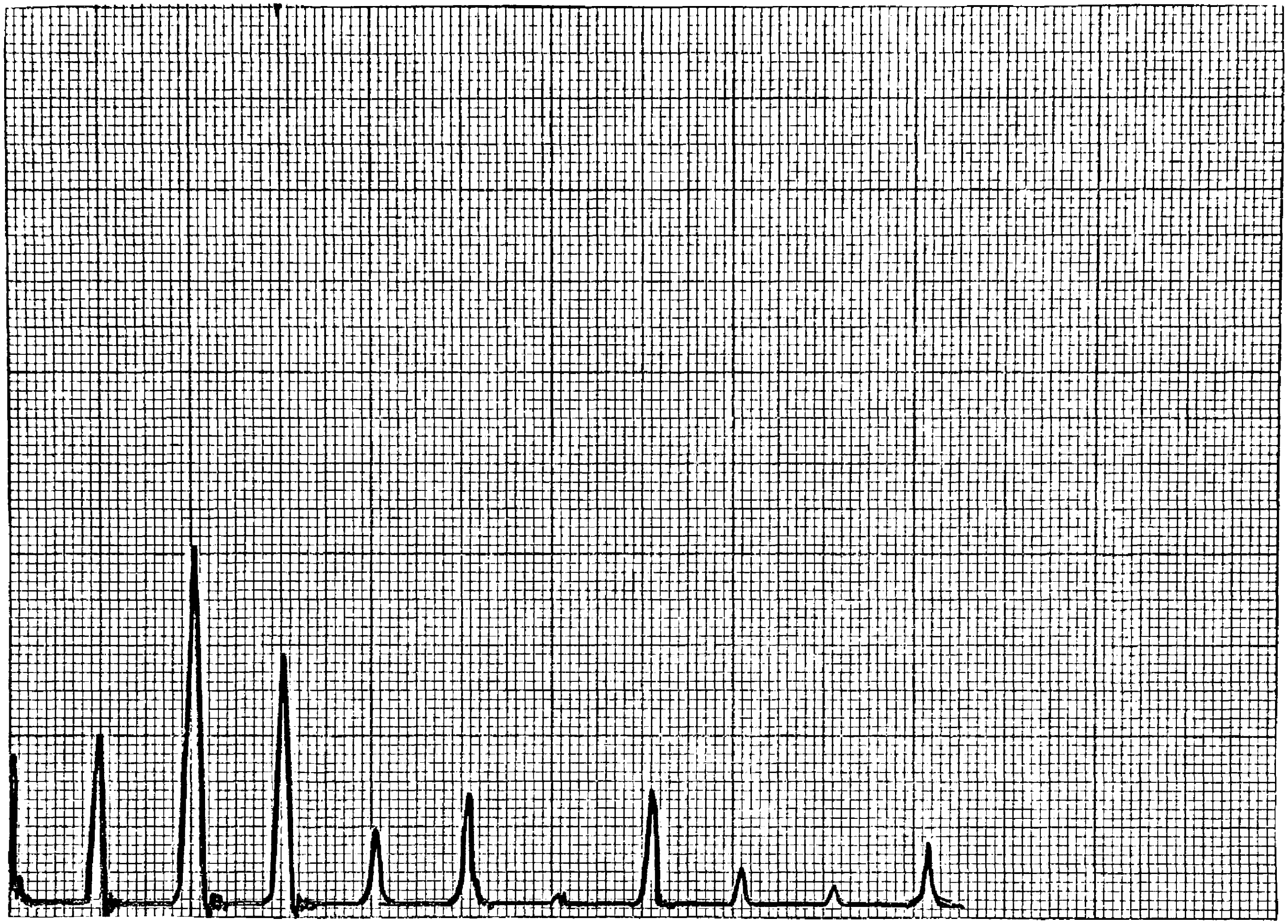


Spectrum Analysis Graph: Group II, Subject Number 18, Pitch e^b.

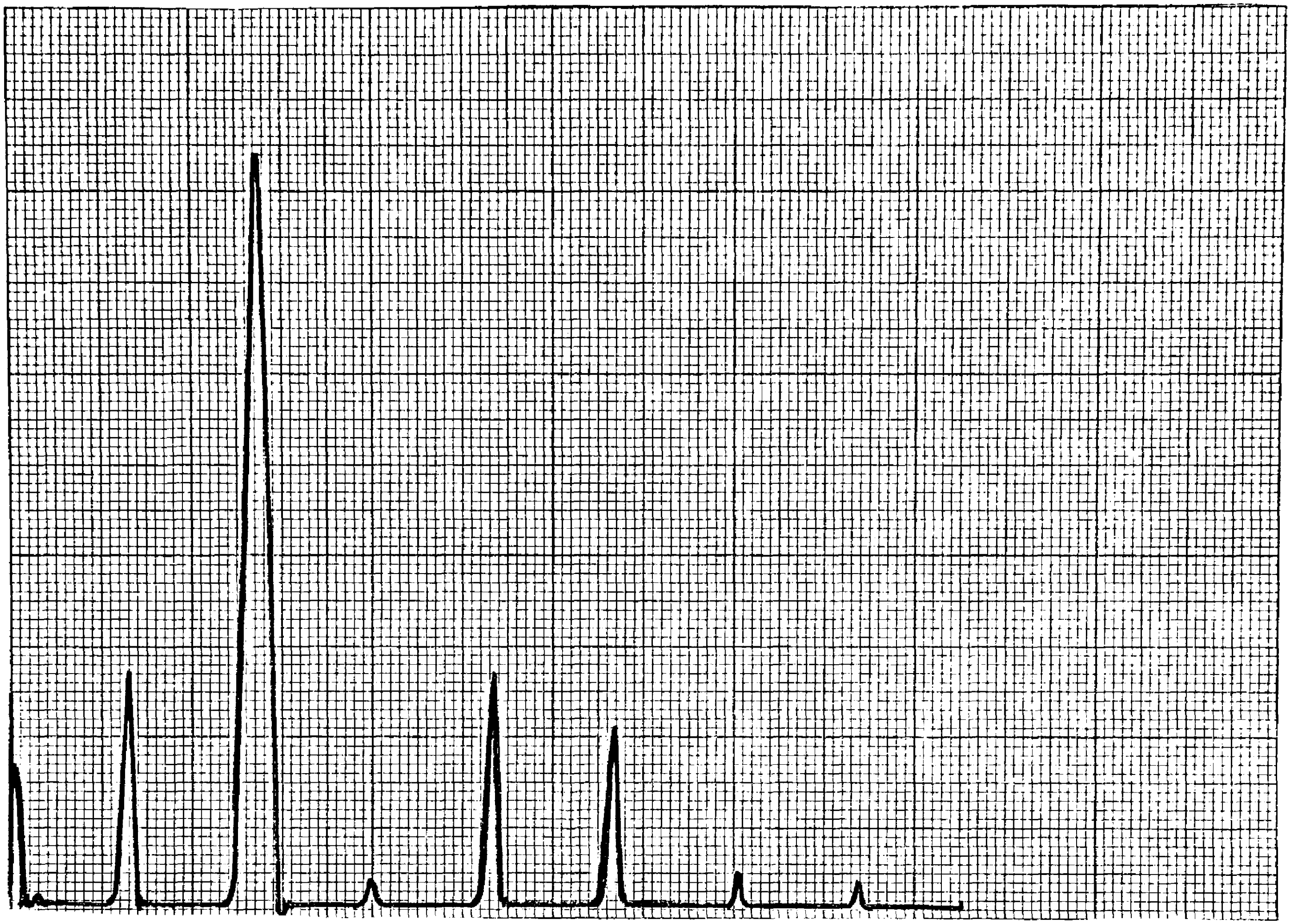
Spectrum Analysis Graph: Group II, Subject Number 28, Pitch d.



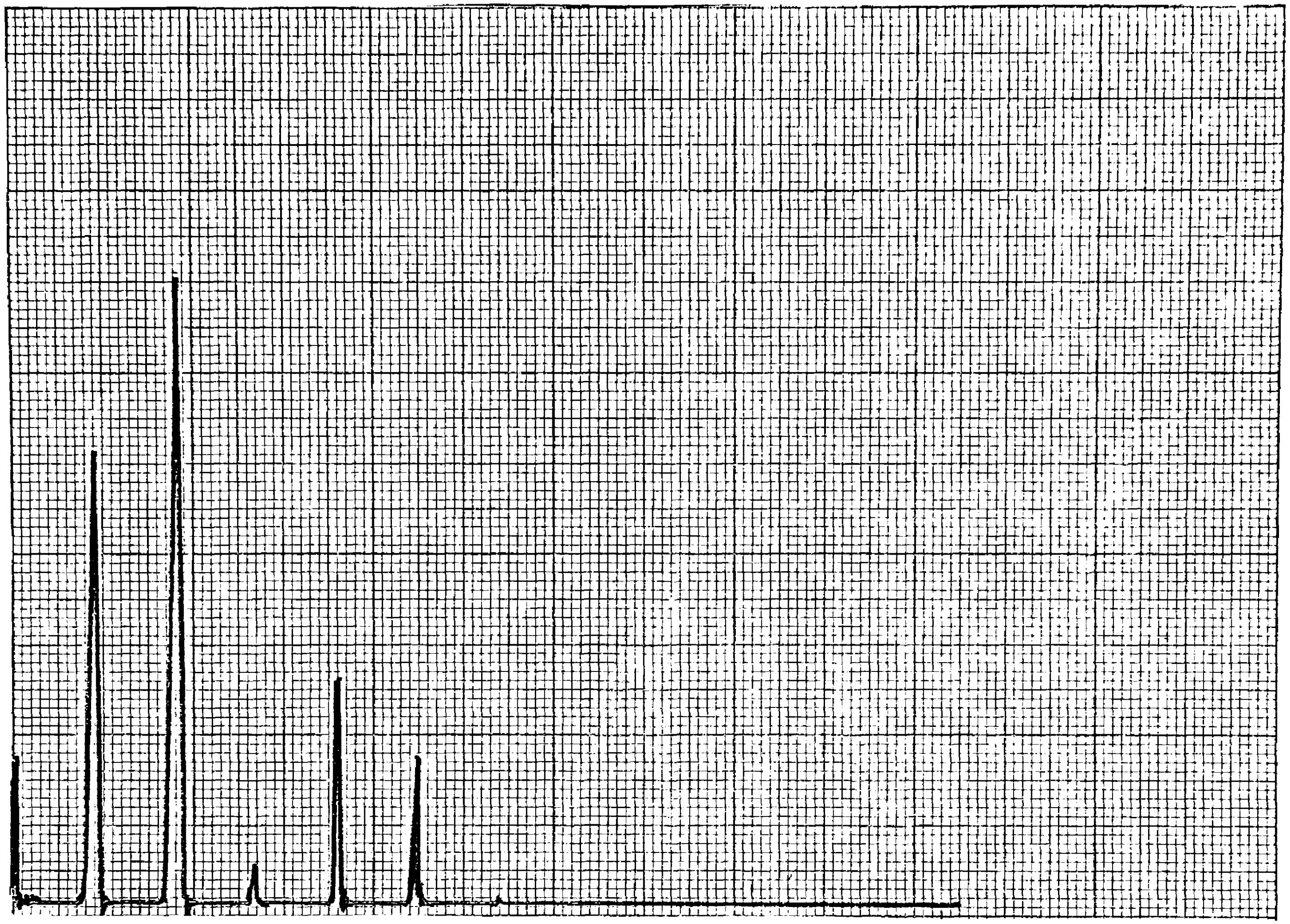
Spectrum Analysis Graph: Group II, Subject Number 28, Pitch g.



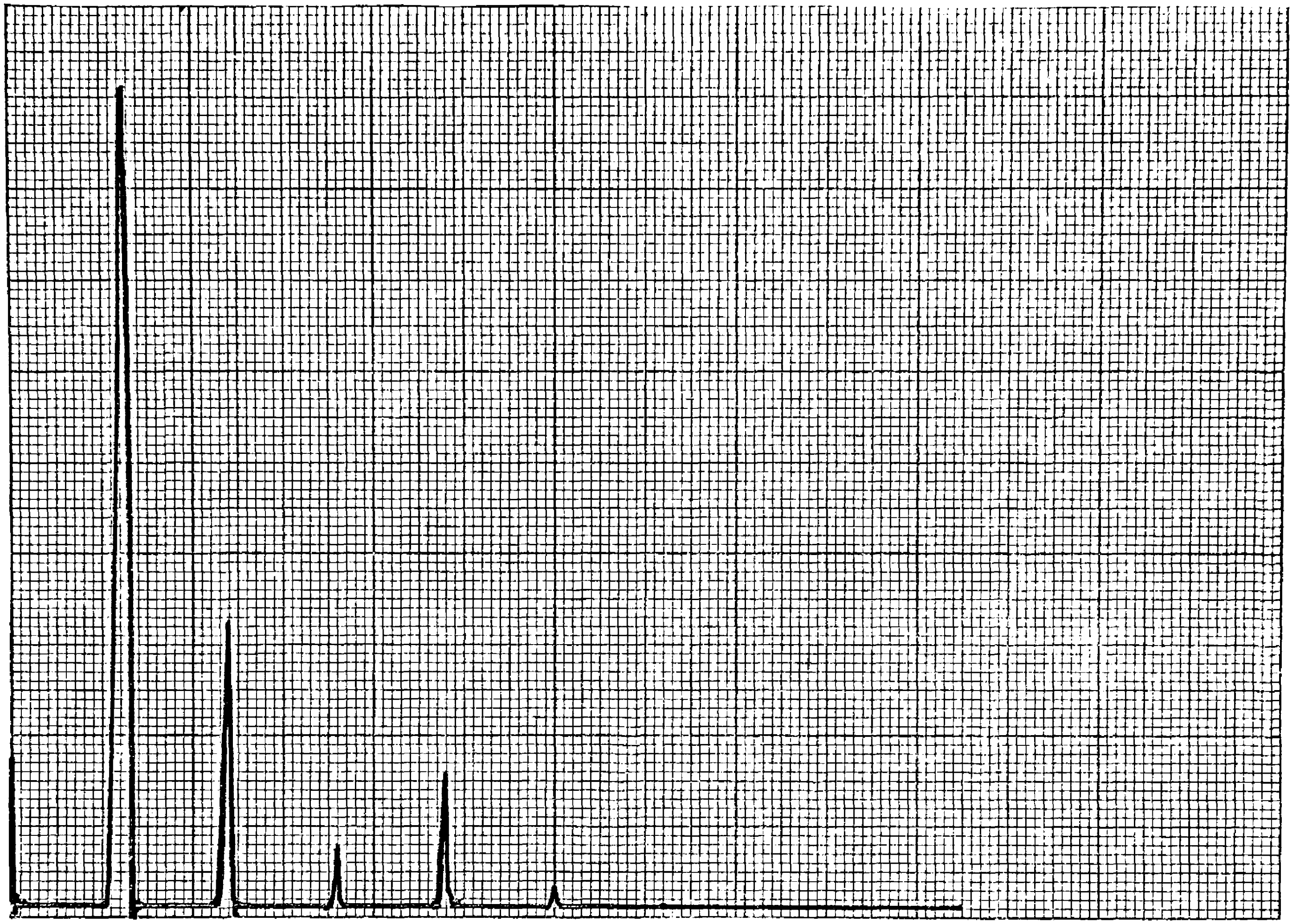
Spectrum Analysis Graph: Group II, Subject Number 28, Pitch c.



Spectrum Analysis Graph: Group II, Subject 28, Pitch f.

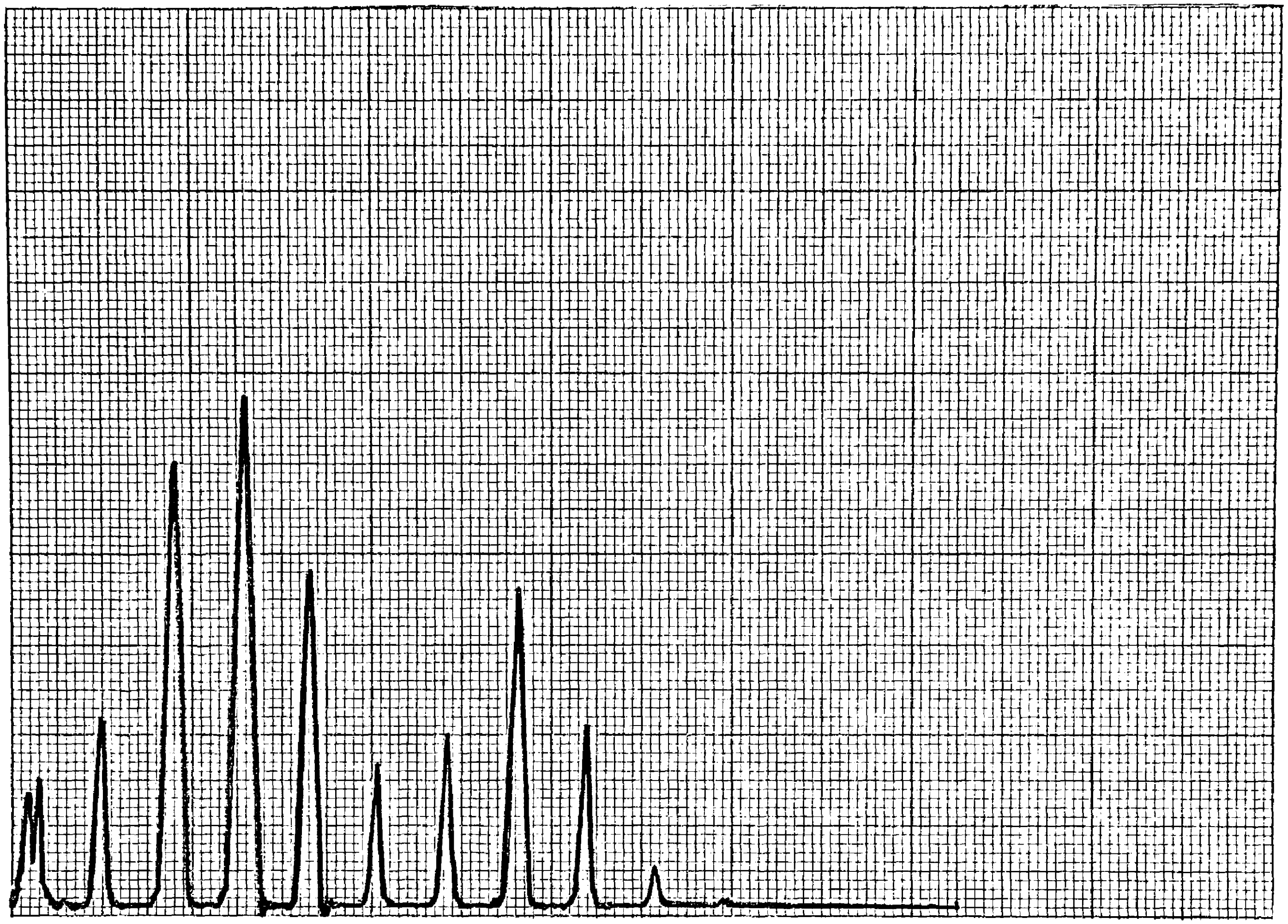


Spectrum Analysis Graph: Group II, Subject Number 28, Pitch b^b.



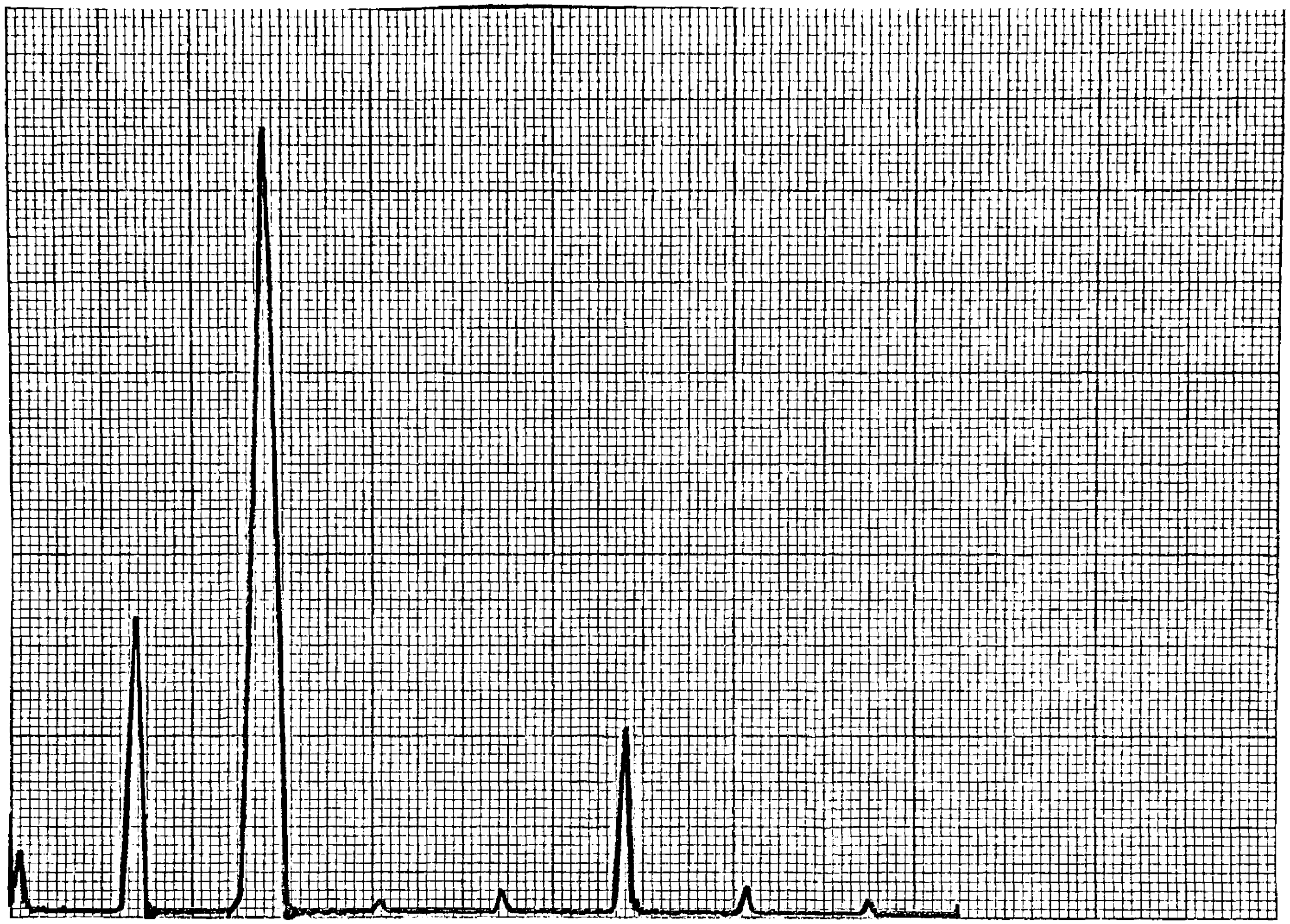
Spectrum Analysis Graph: Group II, Subject Number 28, Pitch e^b.

Spectrum Analysis Graph: Group II, Subject Number 29, Pitch d.

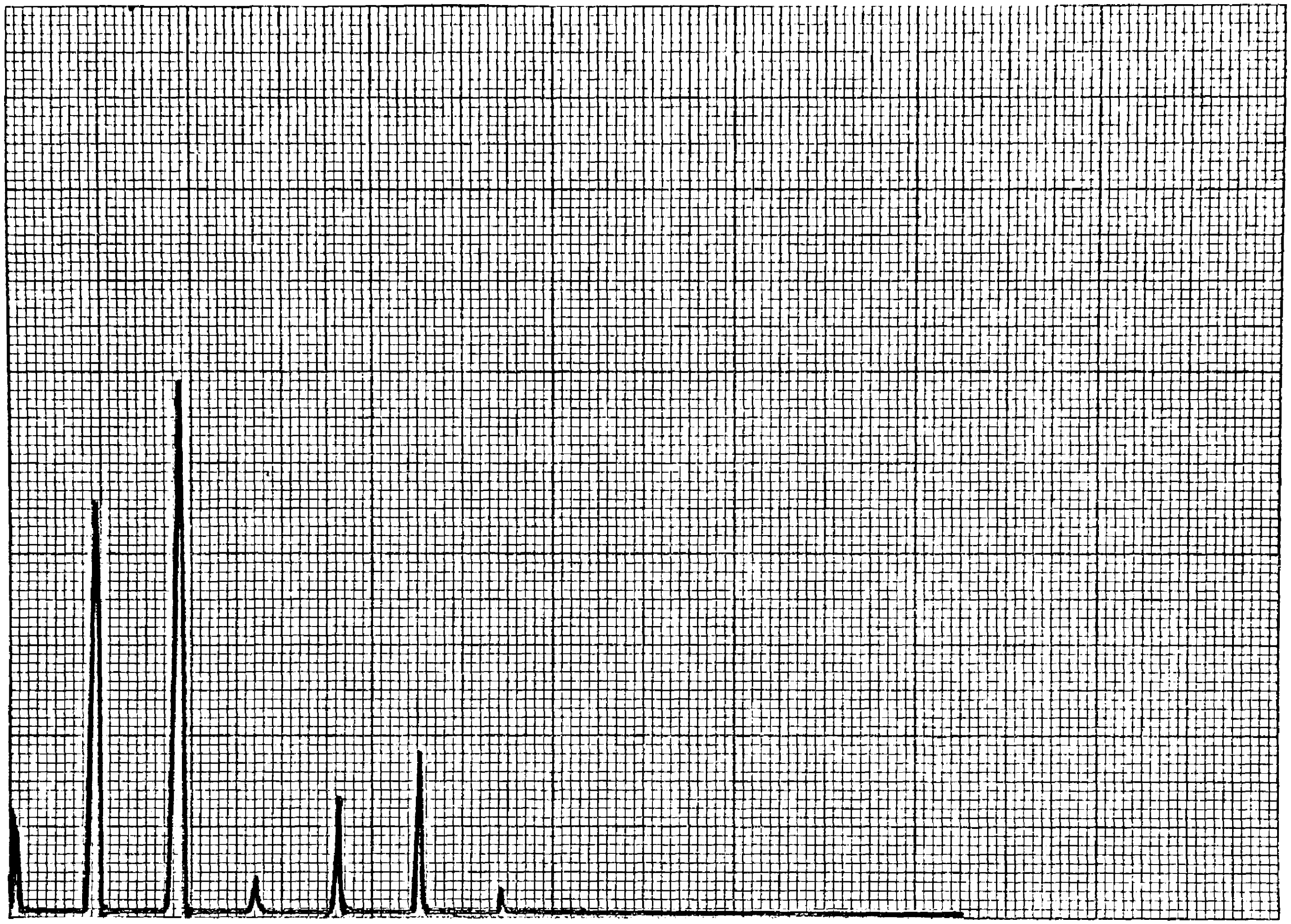


Spectrum Analysis Graph: Group II, Subject Number 29, Pitch g.

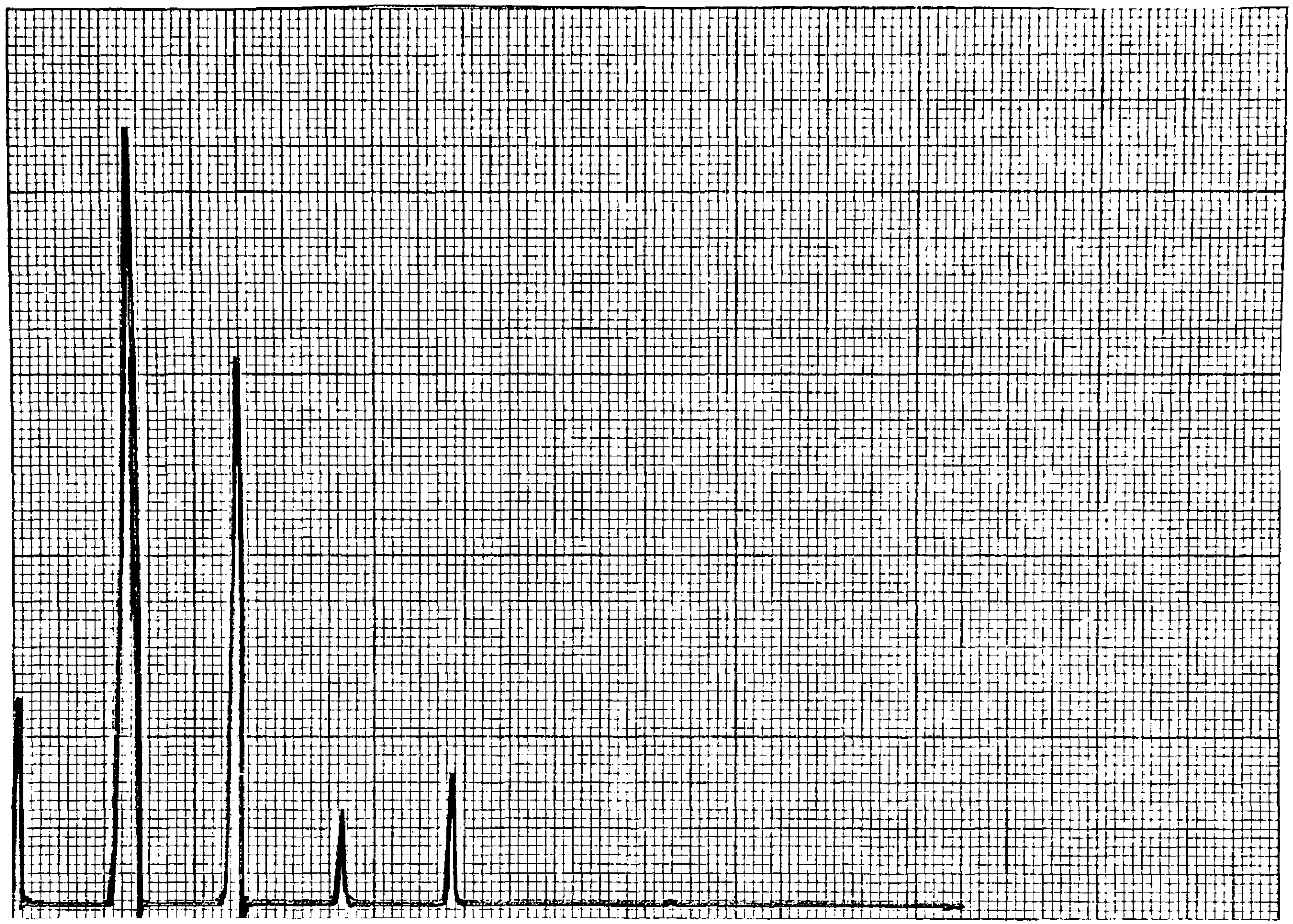
Spectrum Analysis Graph: Group II, Subject Number 29, Pitch c.



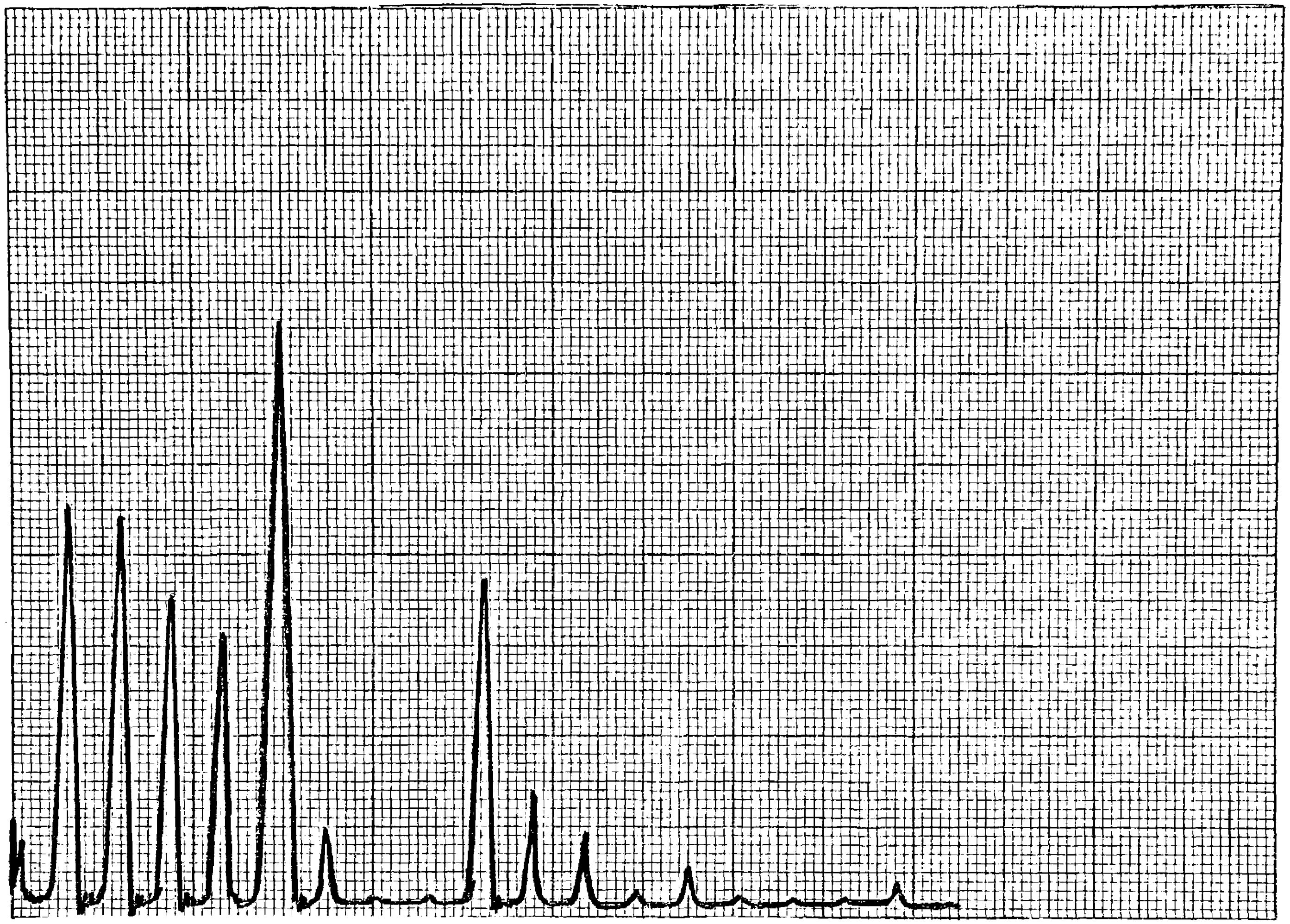
Spectrum Analysis Graph: Group II, Subject Number 29, Pitch f.



Spectrum Analysis Graph: Group II, Subject Number 29, Pitch b^b.



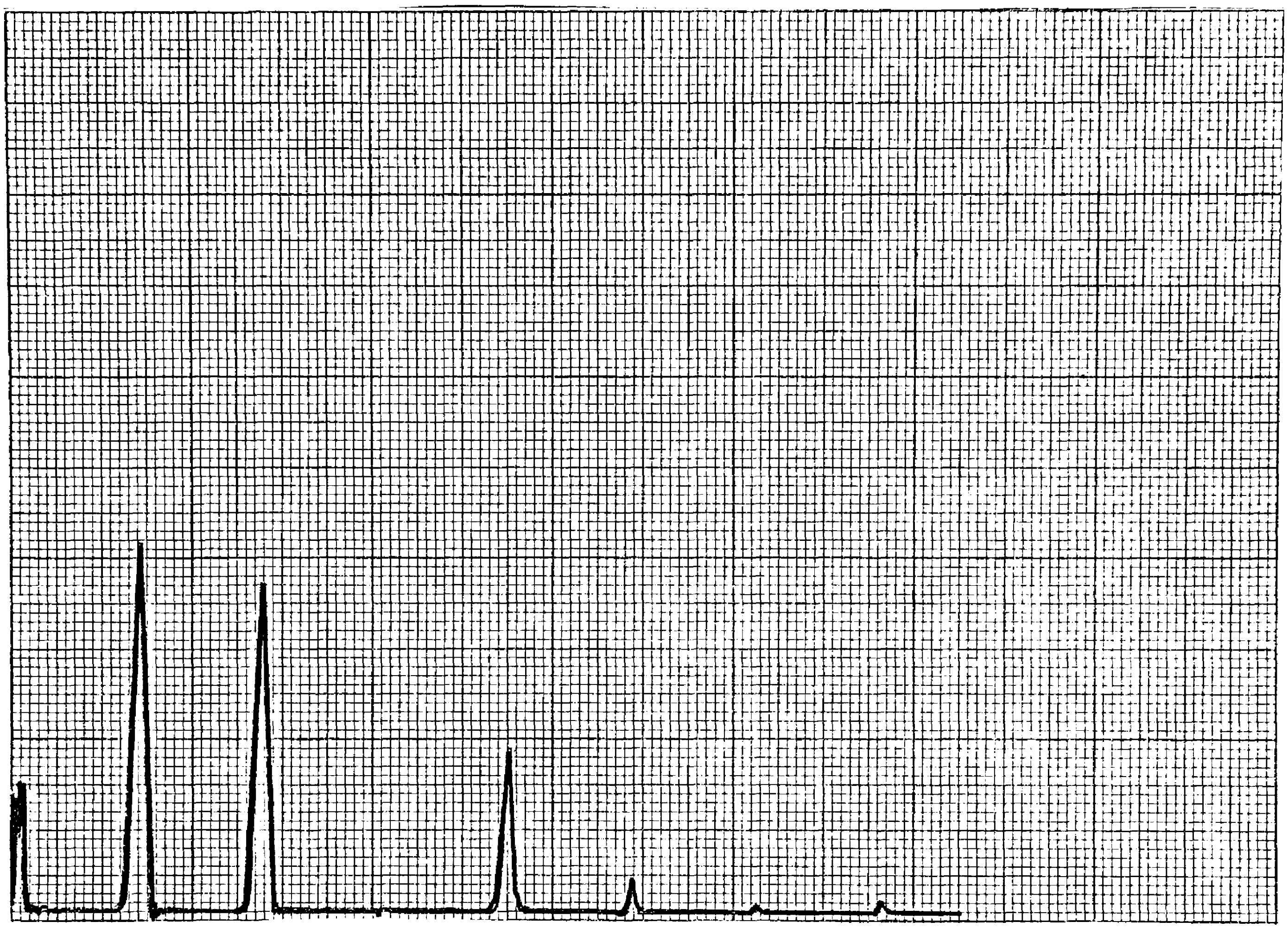
Spectrum Analysis Graph: Group II, Subject Number 29, Pitch e^{b}.



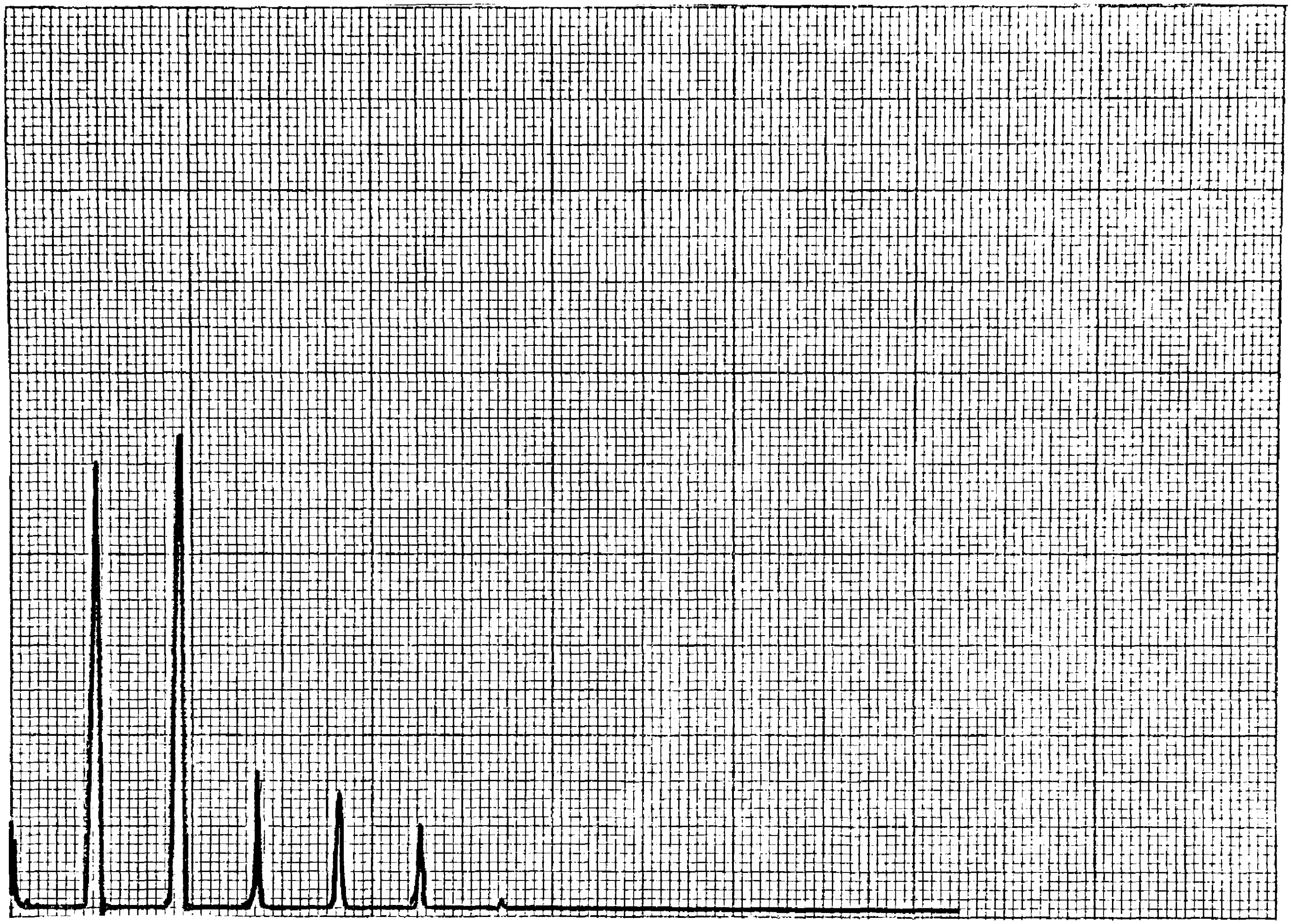
Spectrum Analysis Graph: Group II, Subject Number 30, Pitch d.

Spectrum Analysis Graph: Group II, Subject Number 30, Pitch g.

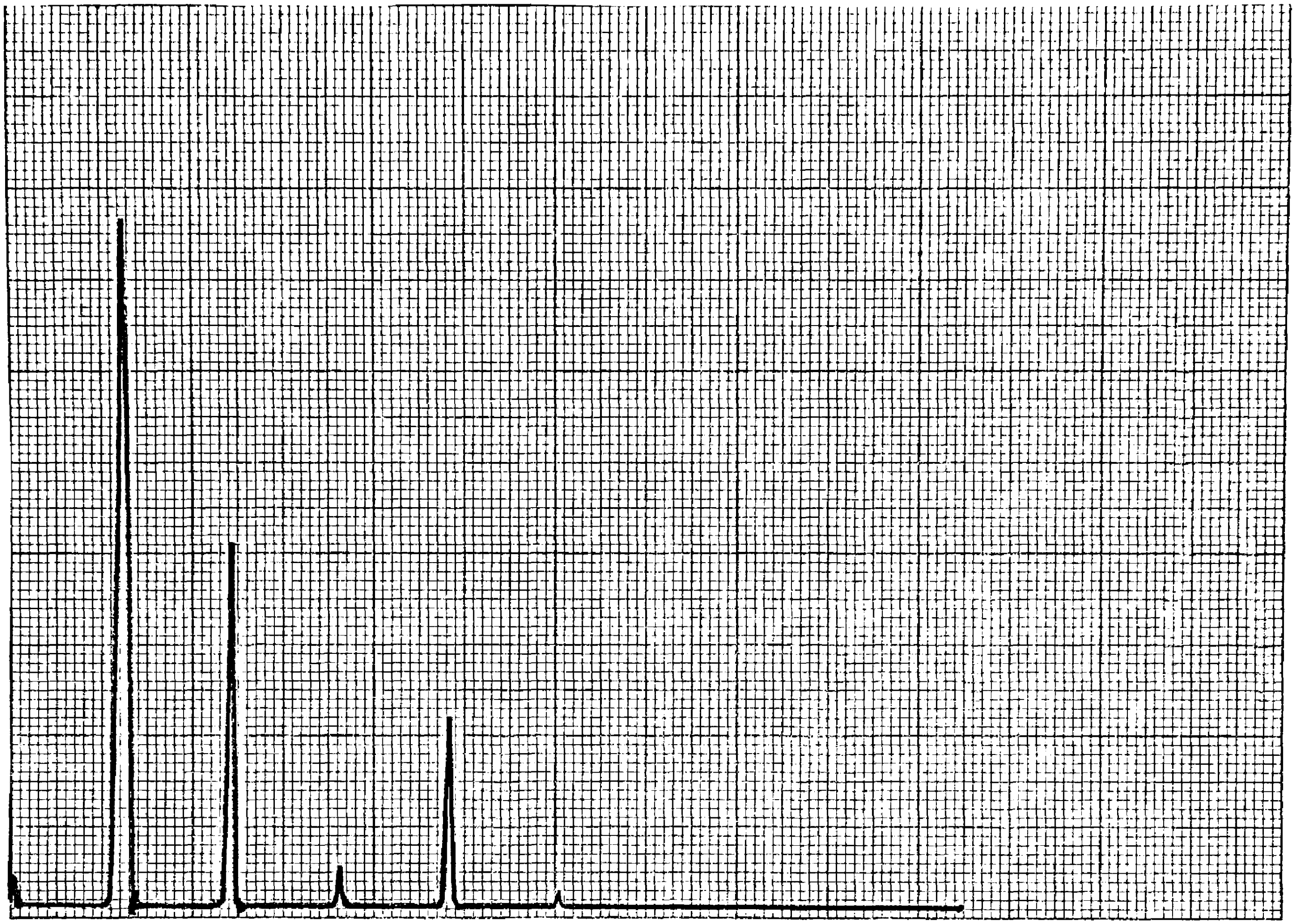
Spectrum Analysis Graph: Group II, Subject Number 30, Pitch c.



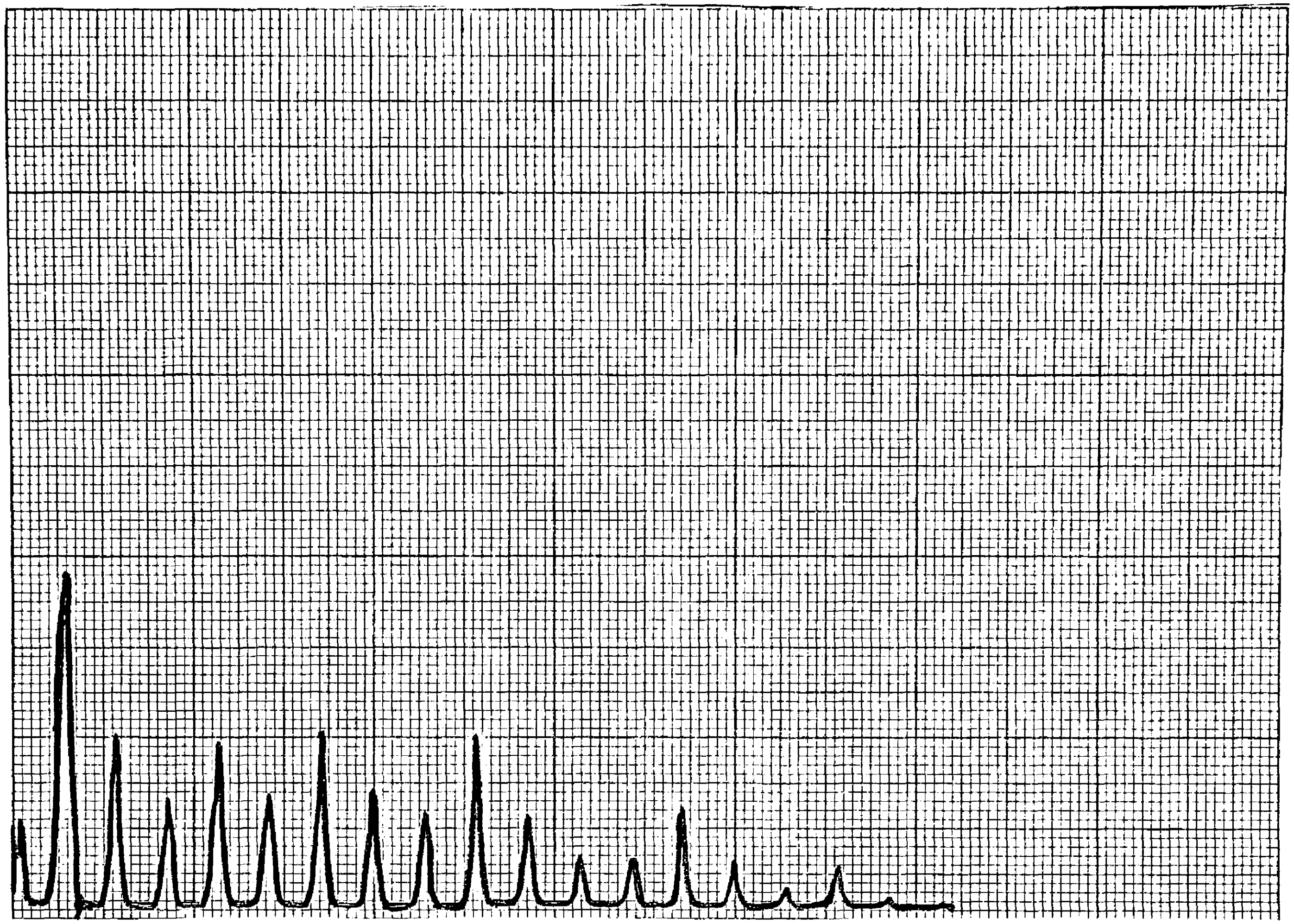
Spectrum Analysis Graph: Group II, Subject Number 30, Pitch f.



Spectrum Analysis Graph: Group II, Subject Number 30, Pitch b^b.



Spectrum Analysis Graph: Group II, Subject Number 30, Pitch e^b.

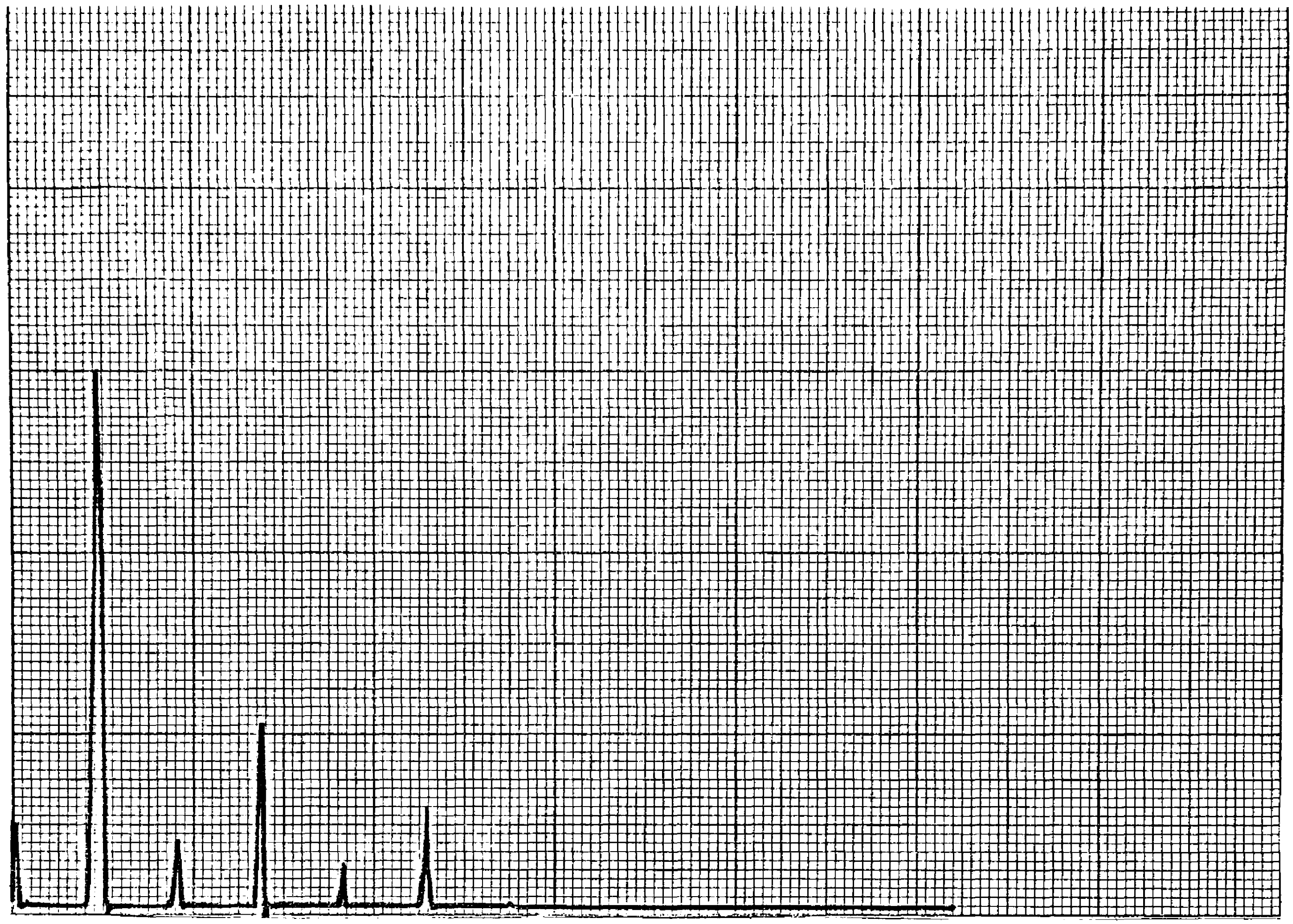


Spectrum Analysis Graph: Group II, Subject Number 40, Pitch d.

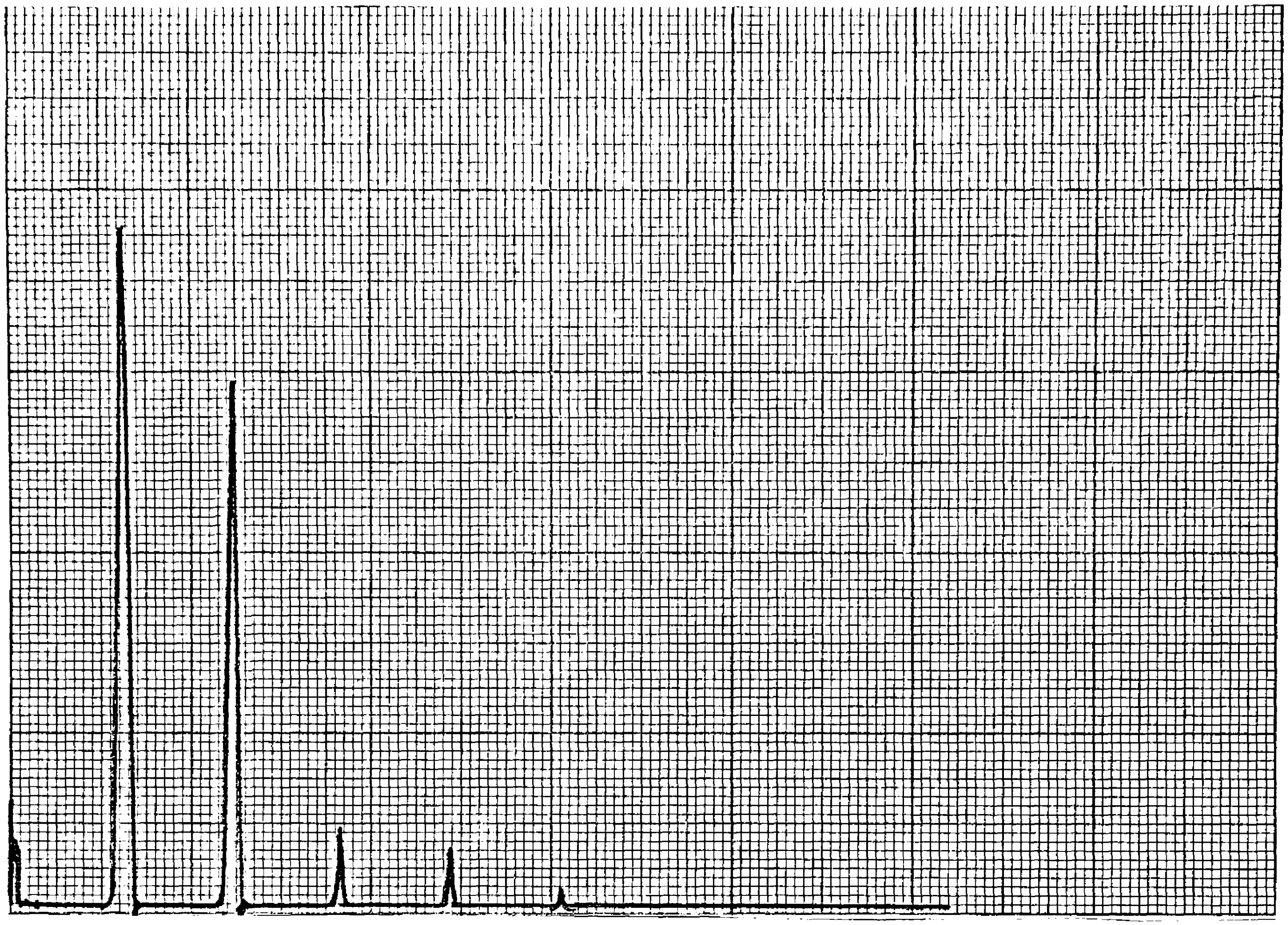
Spectrum Analysis Graph: Group II, Subject Number 40, Pitch g.

Spectrum Analysis Graph: Group II, Subject Number 40, Pitch c.

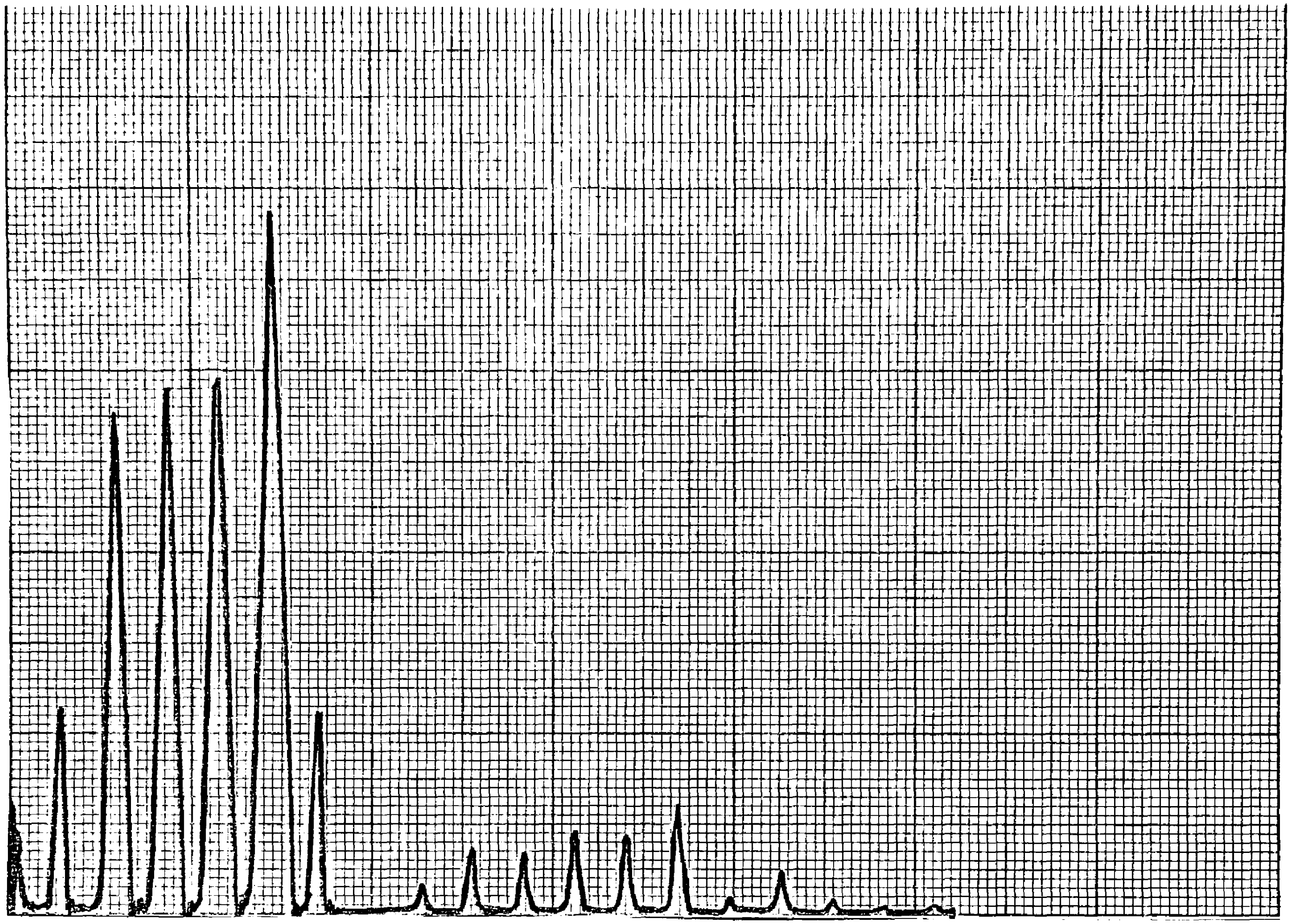
Spectrum Analysis Graph: Group II, Subject Number 40, Pitch f.



Spectrum Analysis Graph: Group II, Subject Number 40, Pitch b^b.



Spectrum Analysis Graph: Group II, Subject Number 40, Pitch e^{b}.

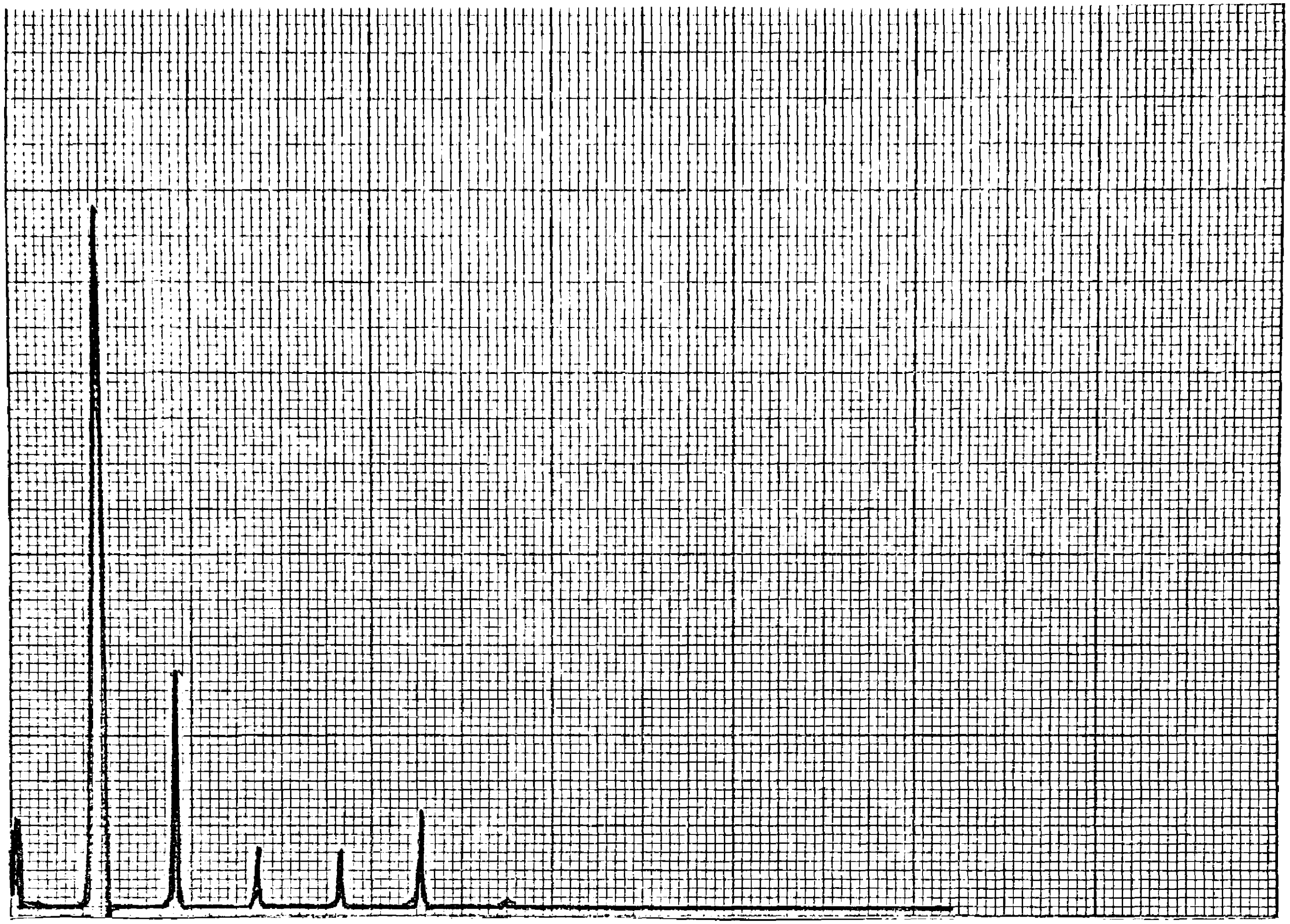


Spectrum Analysis Graph: Group II, Subject Number 41, Pitch d.

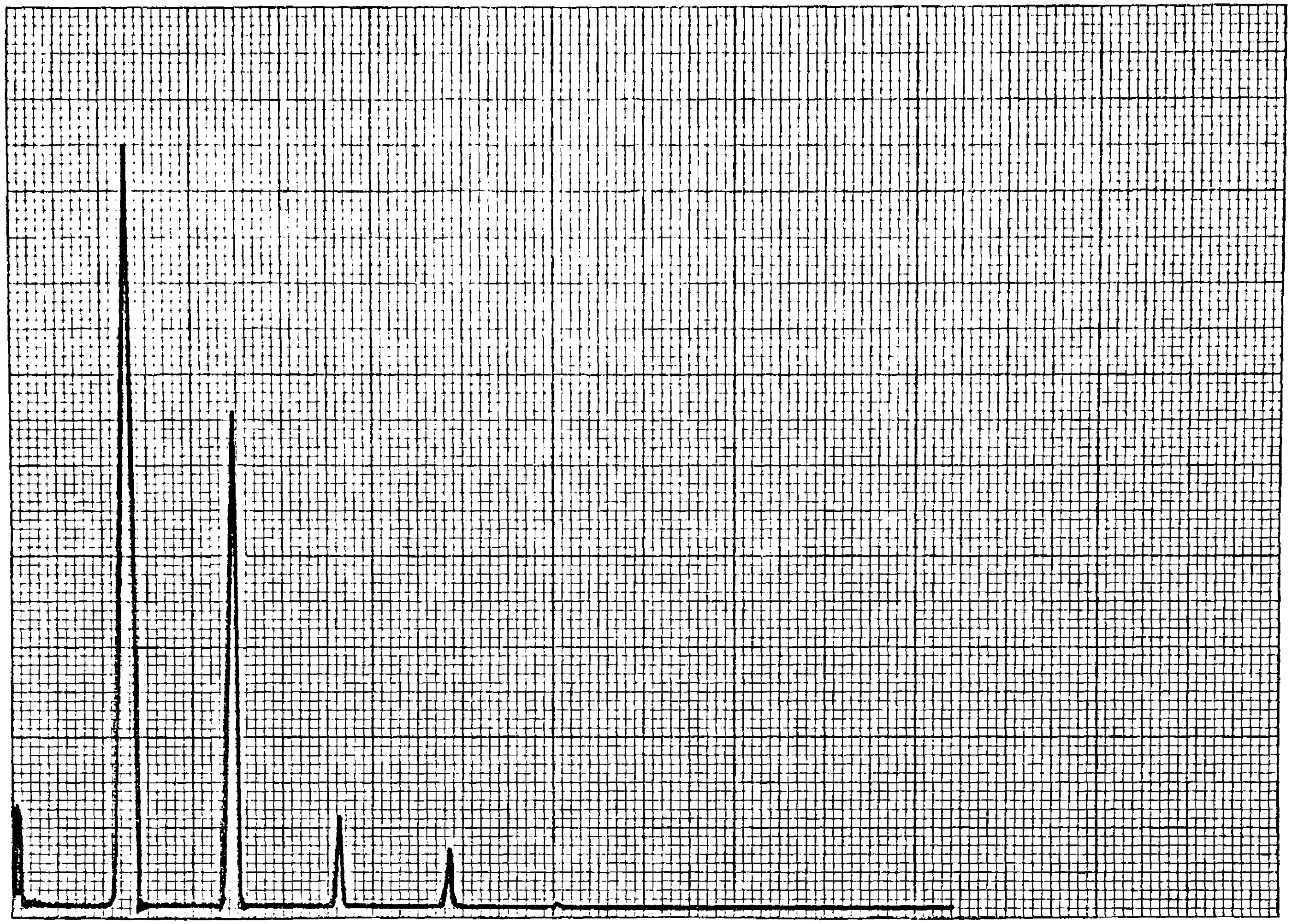
Spectrum Analysis Graph: Group II, Subject Number 41, Pitch g.

Spectrum Analysis Graph: Group II, Subject Number 41, Pitch c.

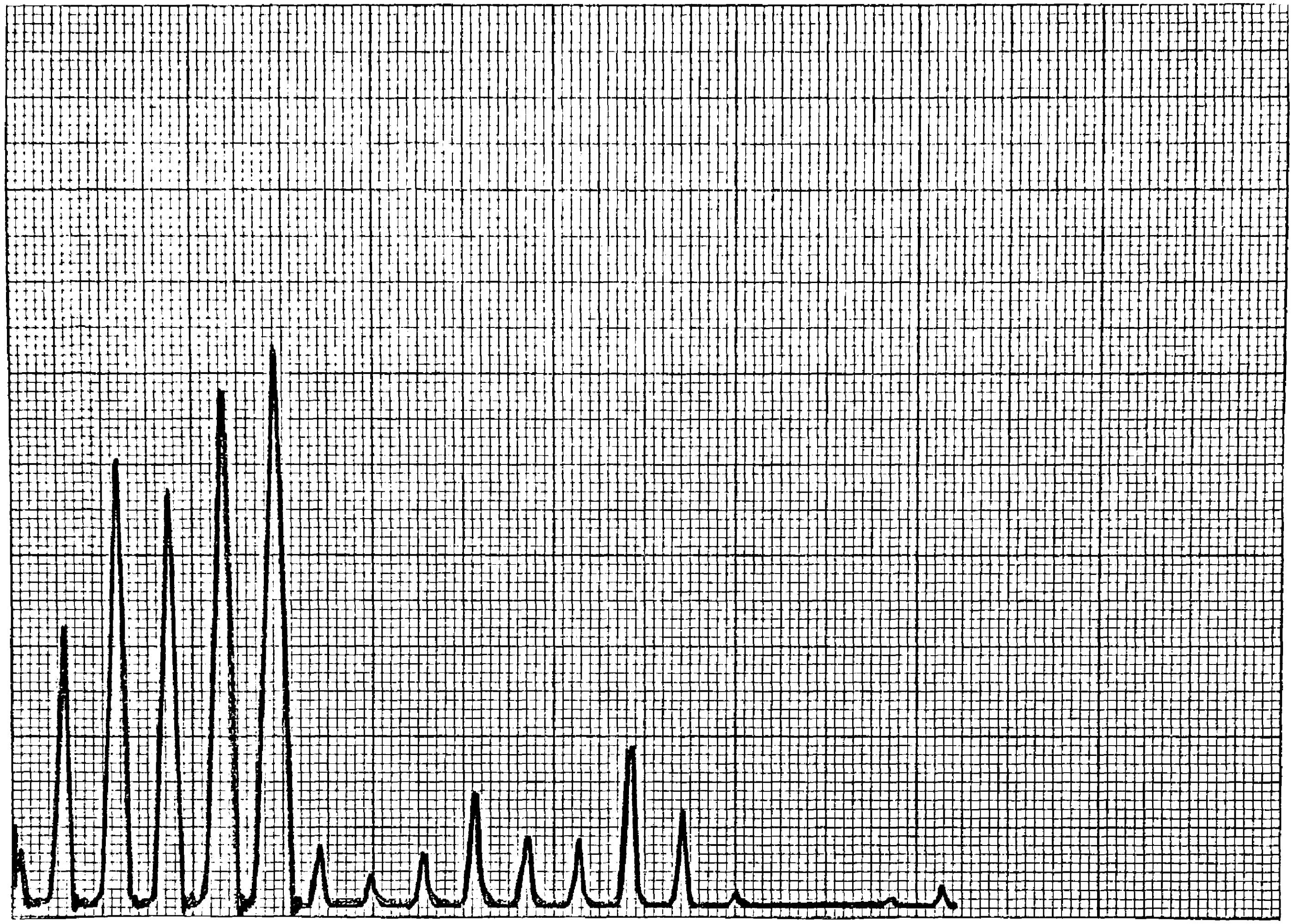
Spectrum Analysis Graph: Group II, Subject Number 41, Pitch f.



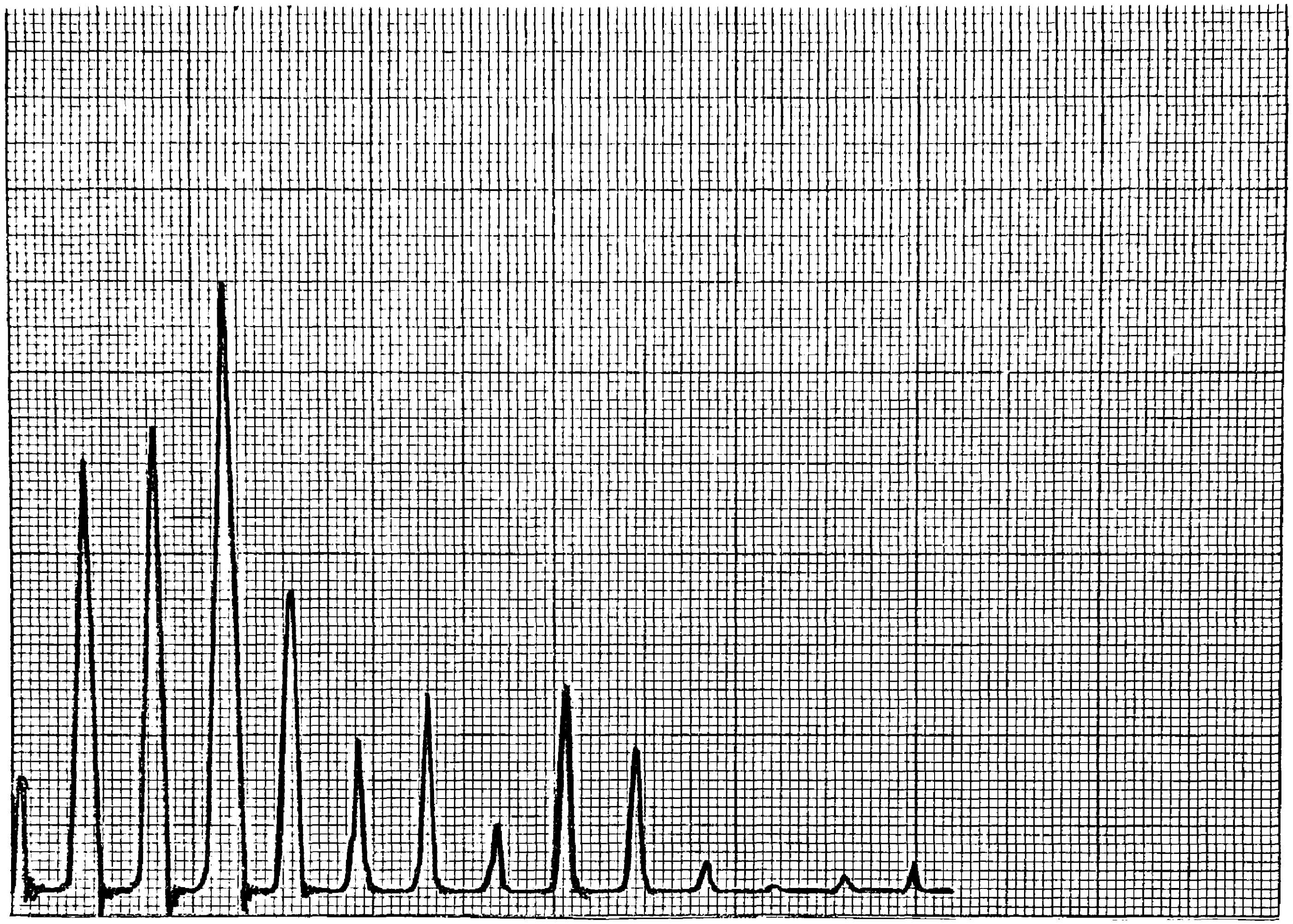
Spectrum Analysis Graph: Group II, Subject Number 41, Pitch b^b.



Spectrum Analysis Graph: Group II, Subject Number 41, Pitch e^b.

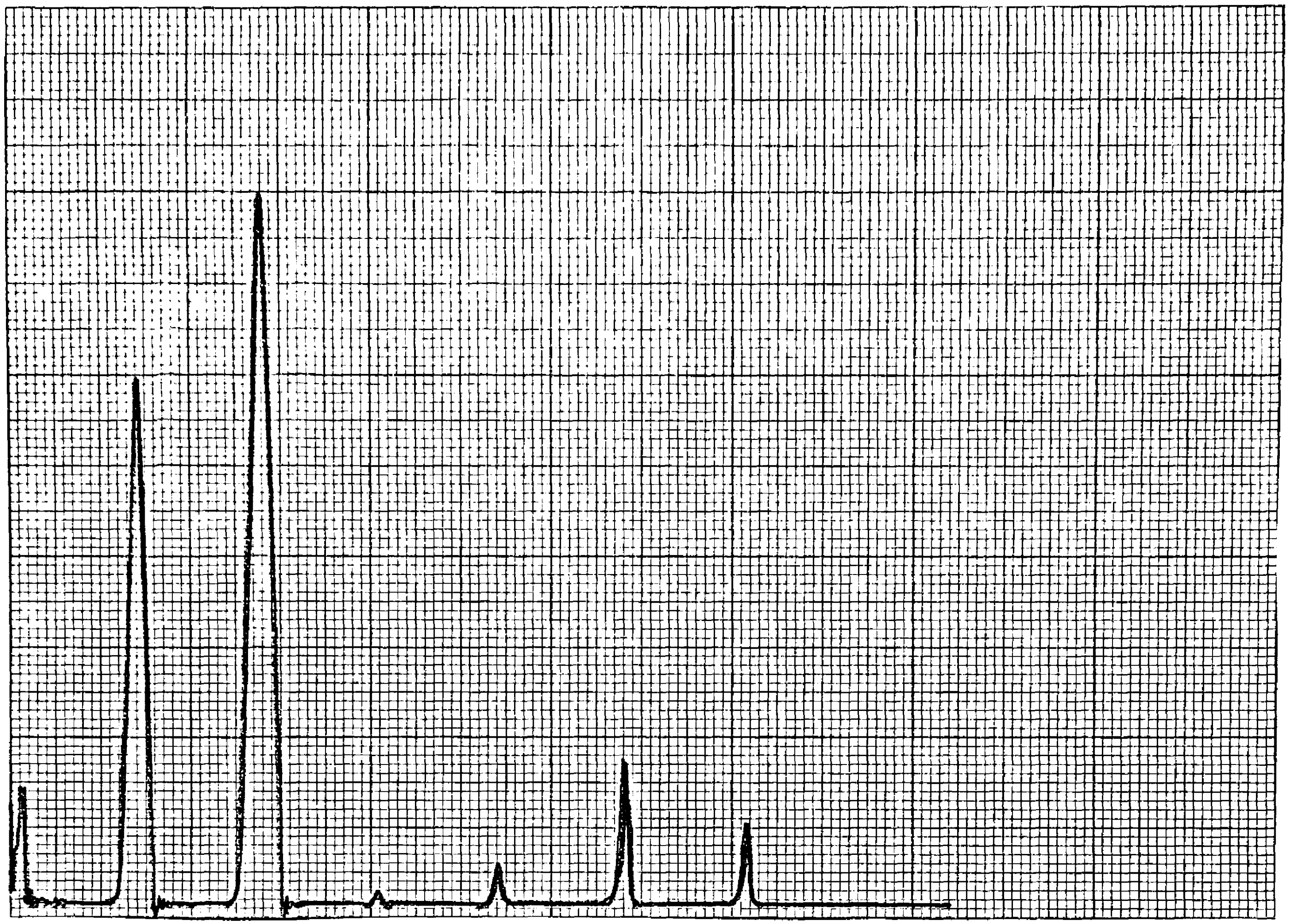


Spectrum Analysis Graph: Group II, Subject Number 42, Pitch d.

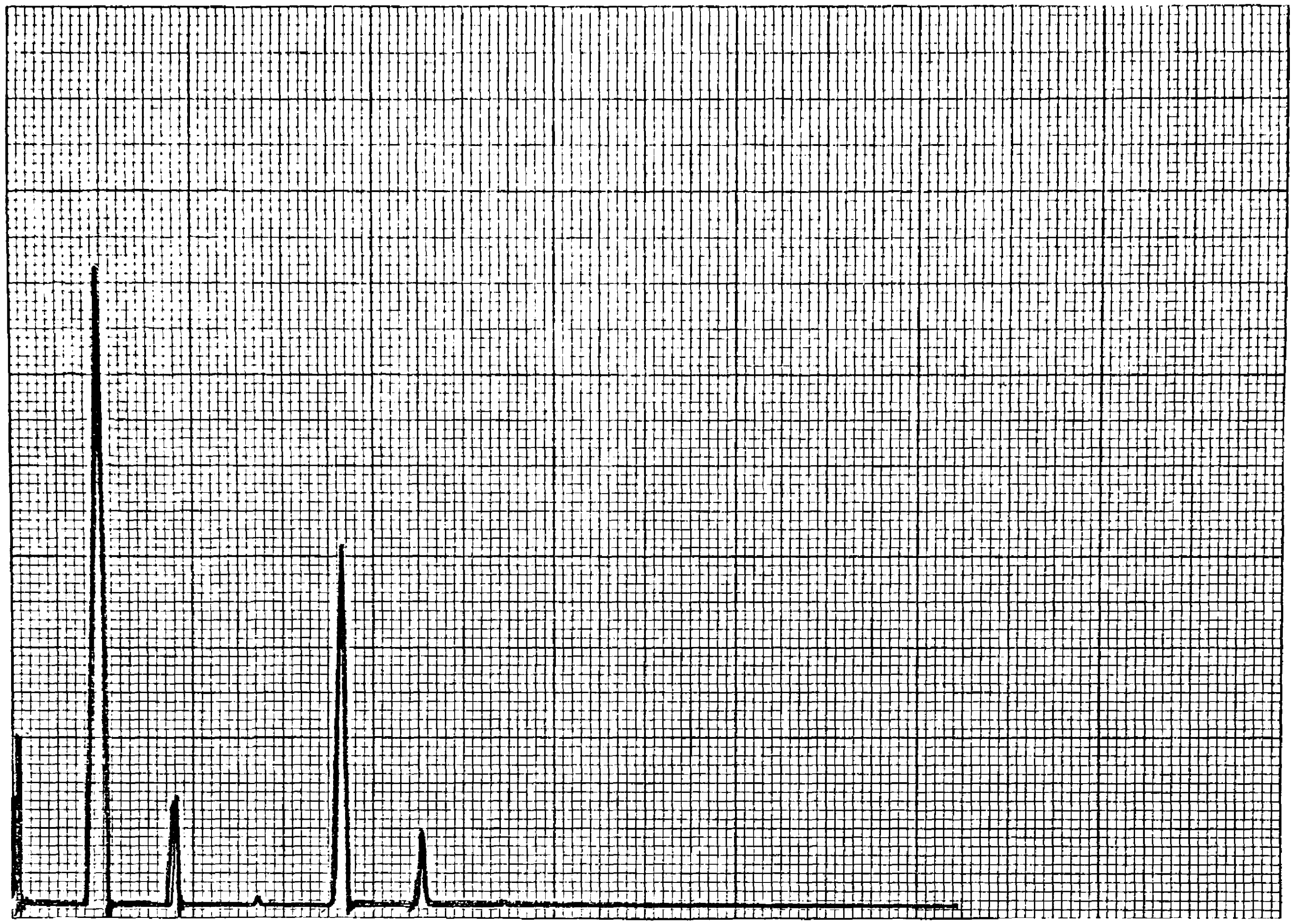


Spectrum Analysis Graph: Group II, Subject Number 42, Pitch g.

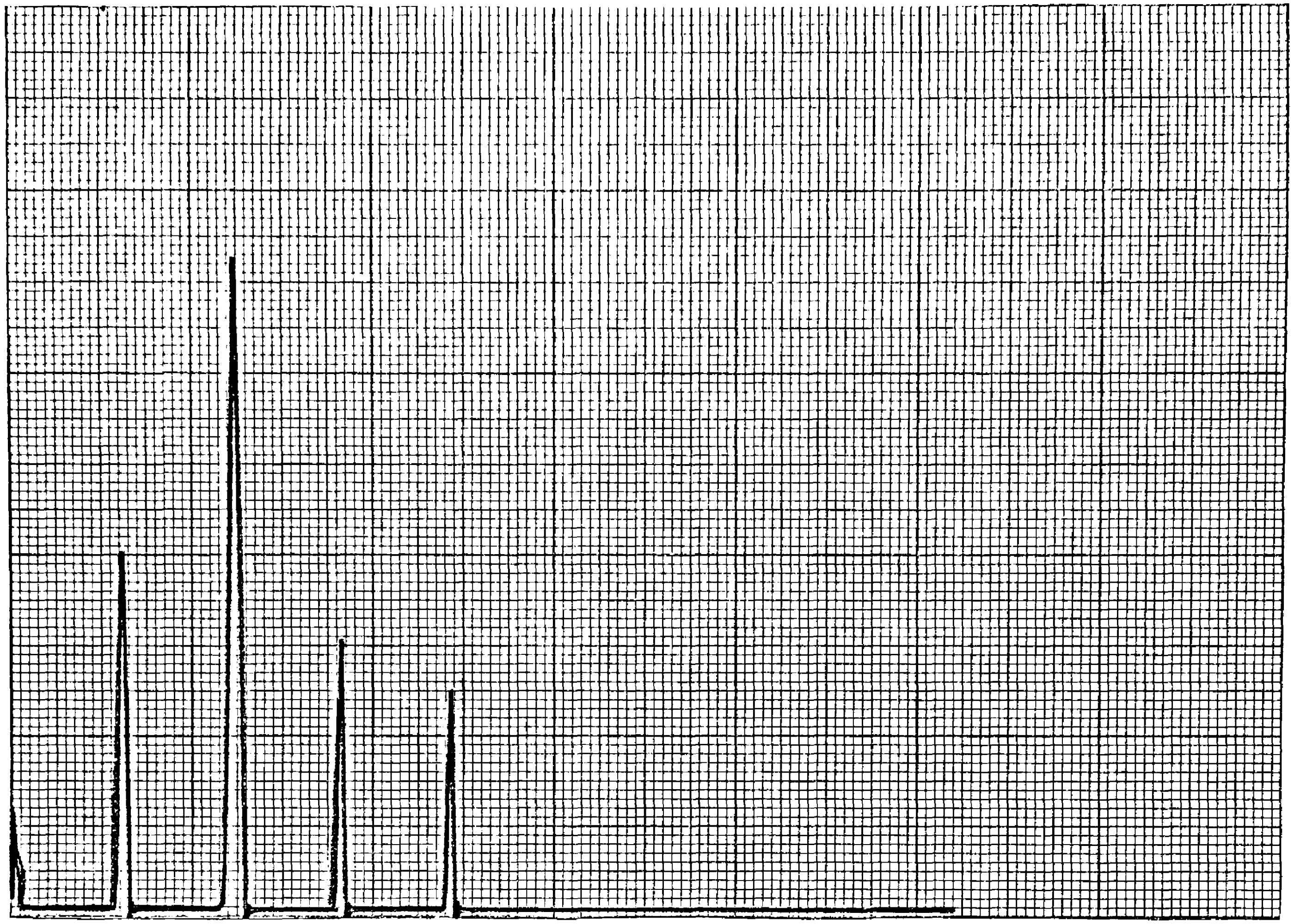
Spectrum Analysis Graph: Group II, Subject Number 42, Pitch c.



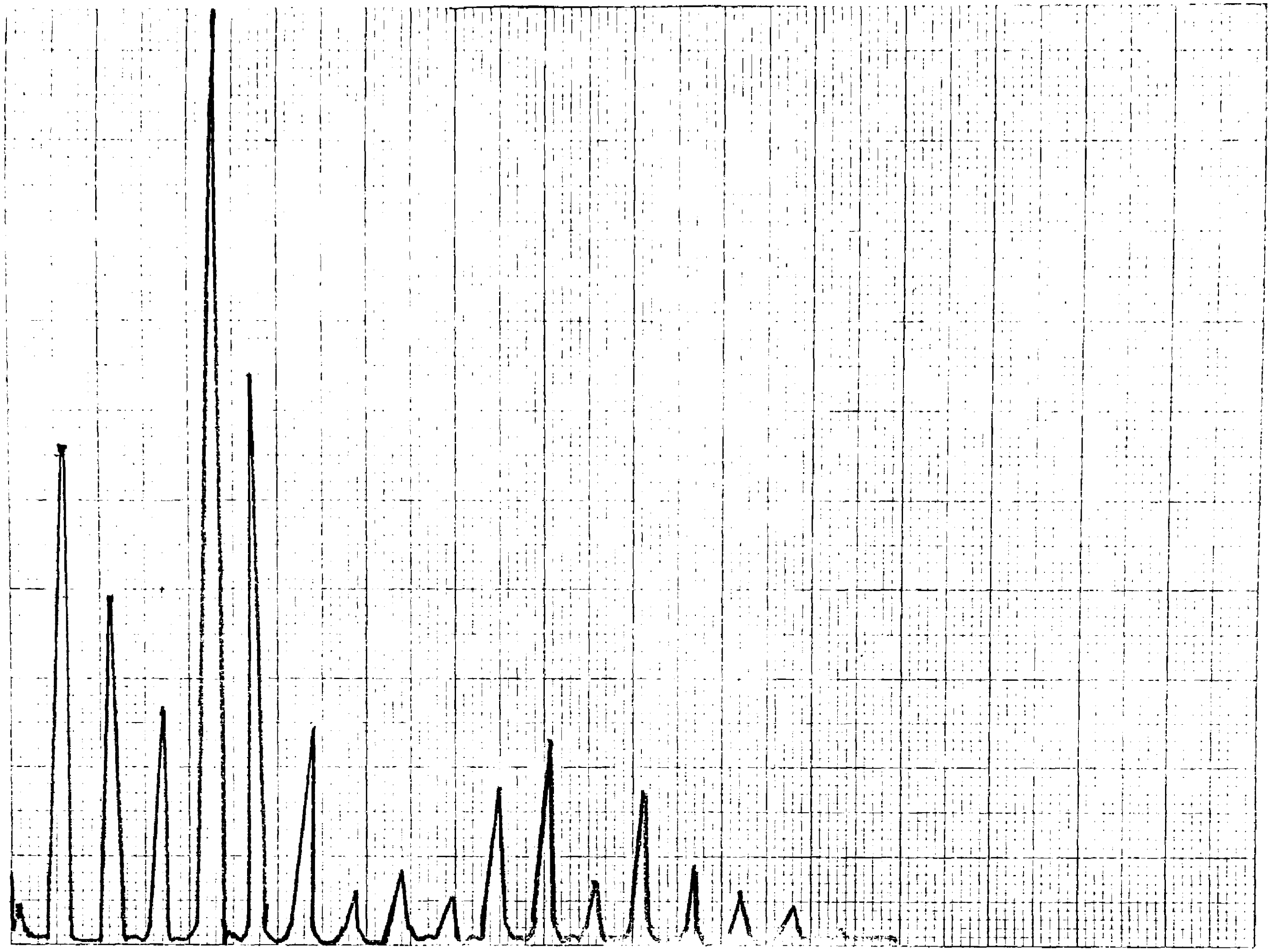
Spectrum Analysis Graph: Group II, Subject Number 42, Pitch f.



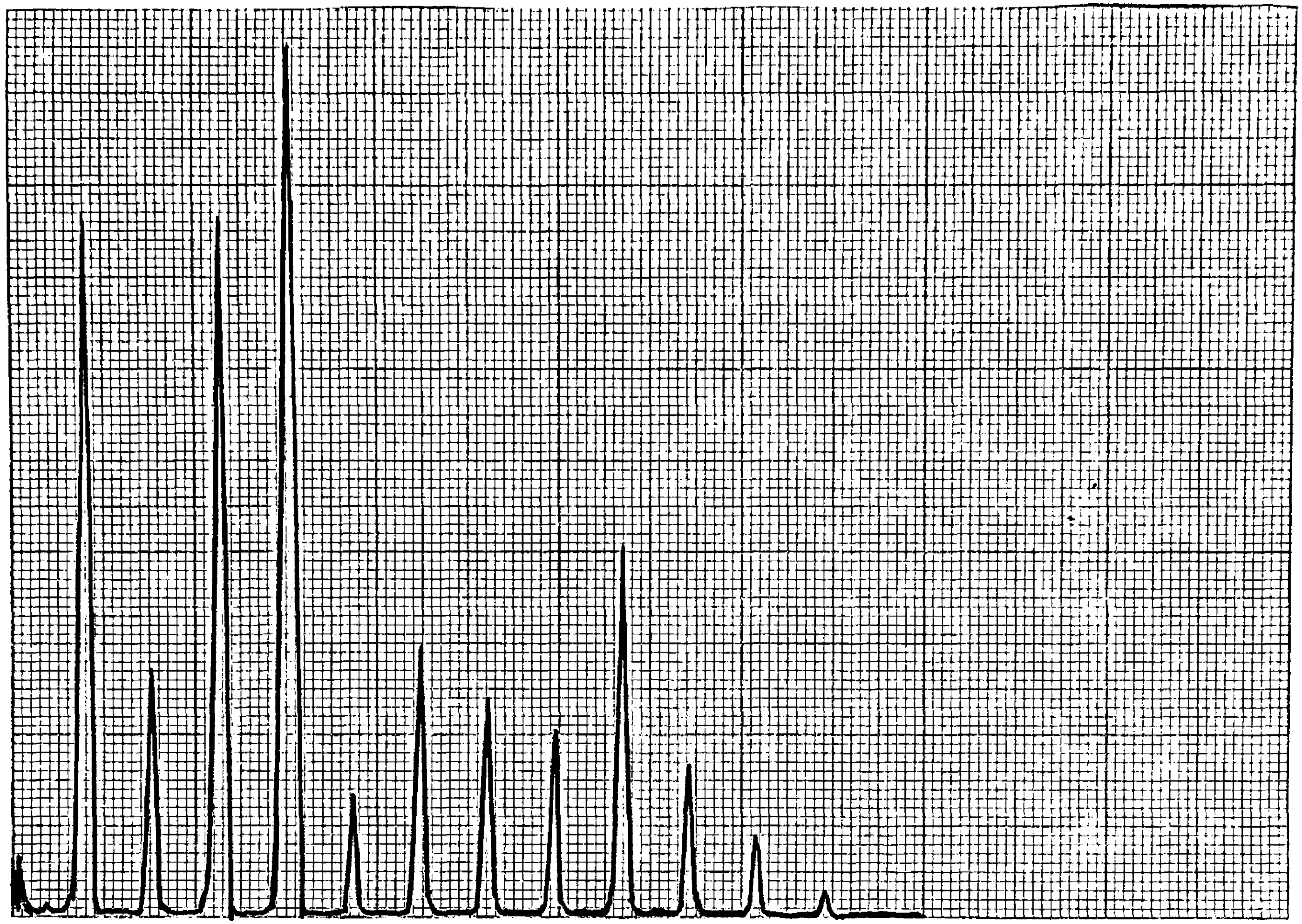
Spectrum Analysis Graph: Group II, Subject Number 42, Pitch b^b.



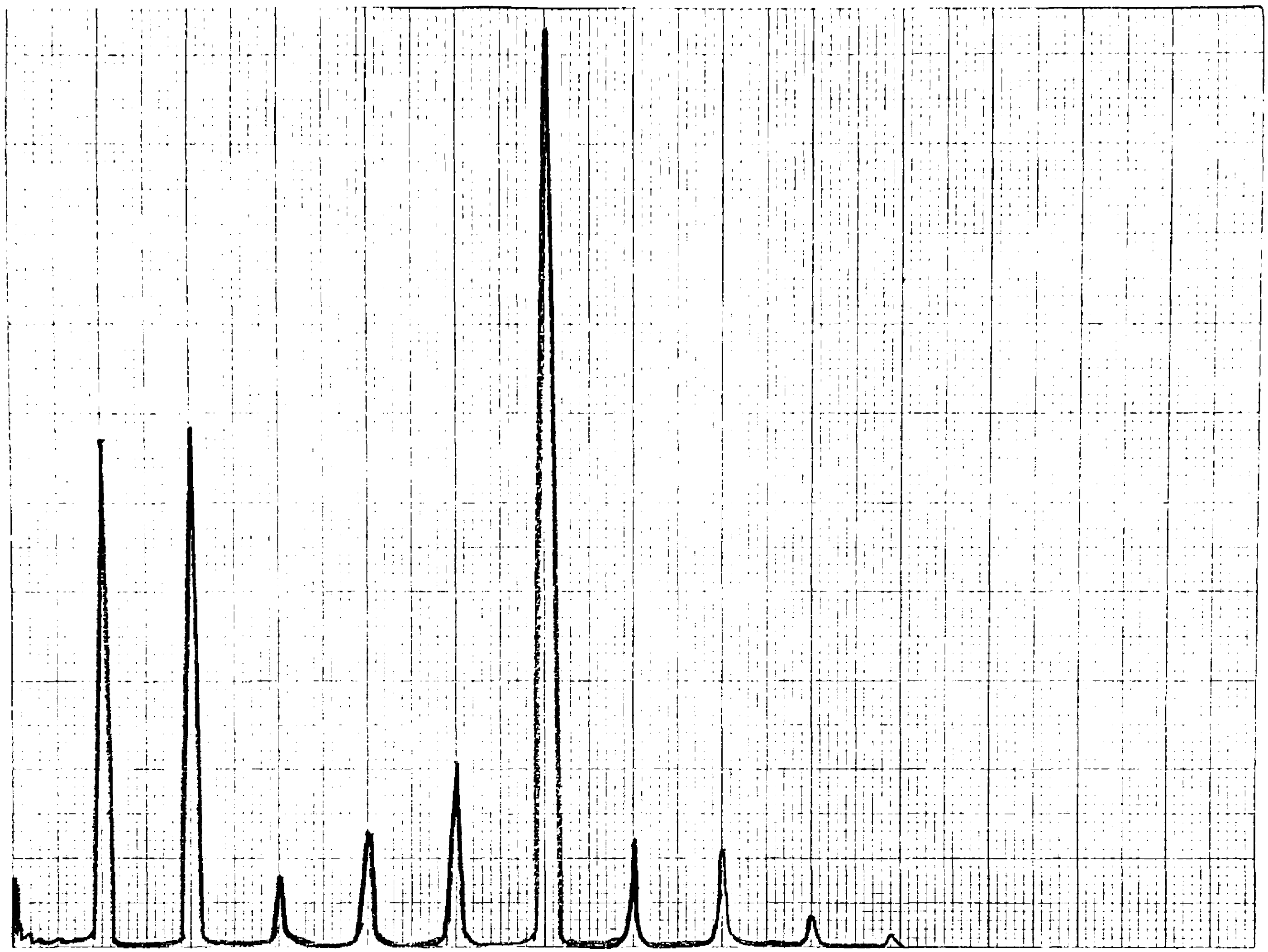
Spectrum Analysis Graph: Group II, Subject Number 42, Pitch e^b.



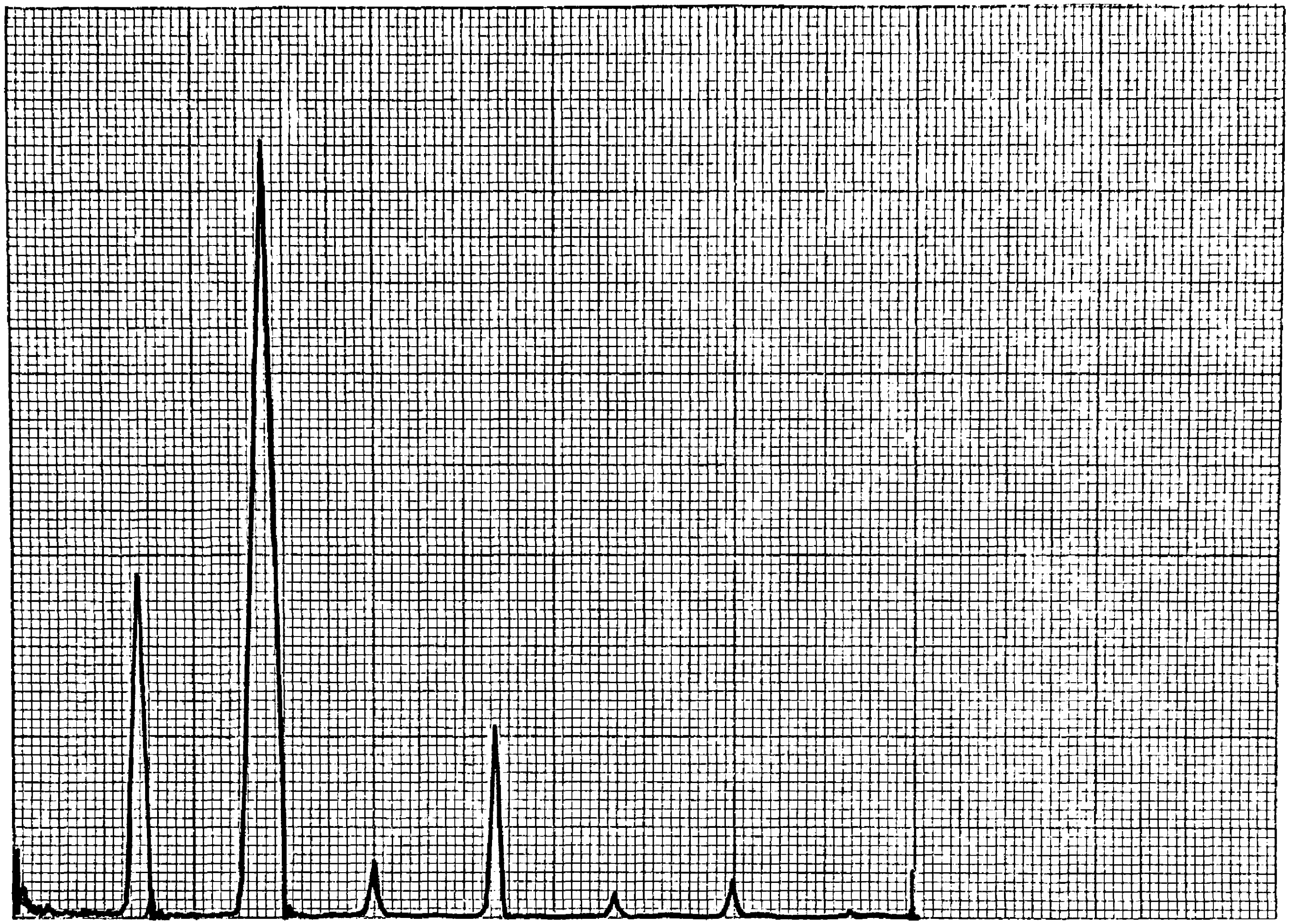
Spectrum Analysis Graph: Group III, Subject Number 7, Pitch d.



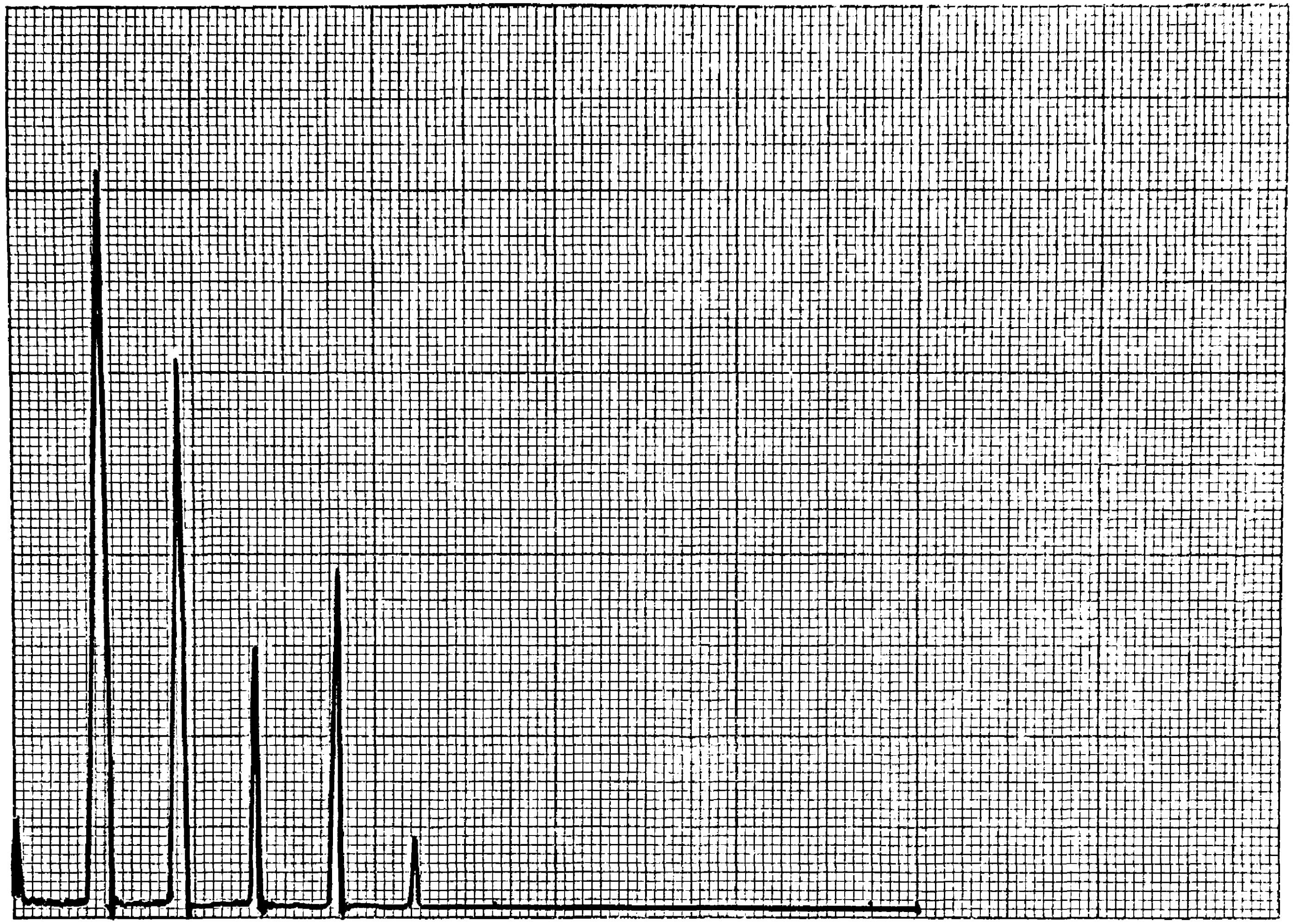
Spectrum Analysis Graph: Group III, Subject Number 7, Pitch g.



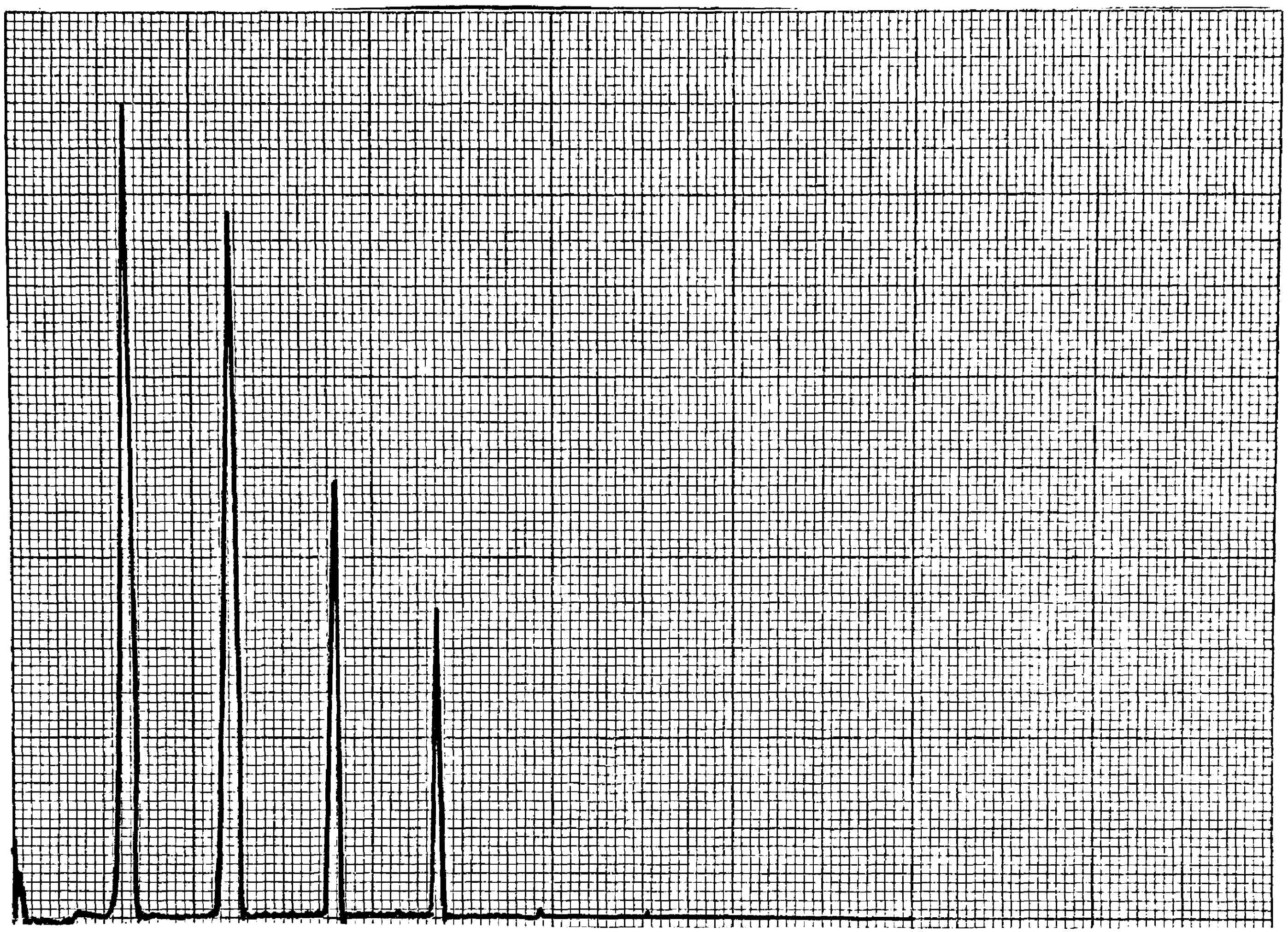
Spectrum Analysis Graph: Group III, Subject Number 7, Pitch c.



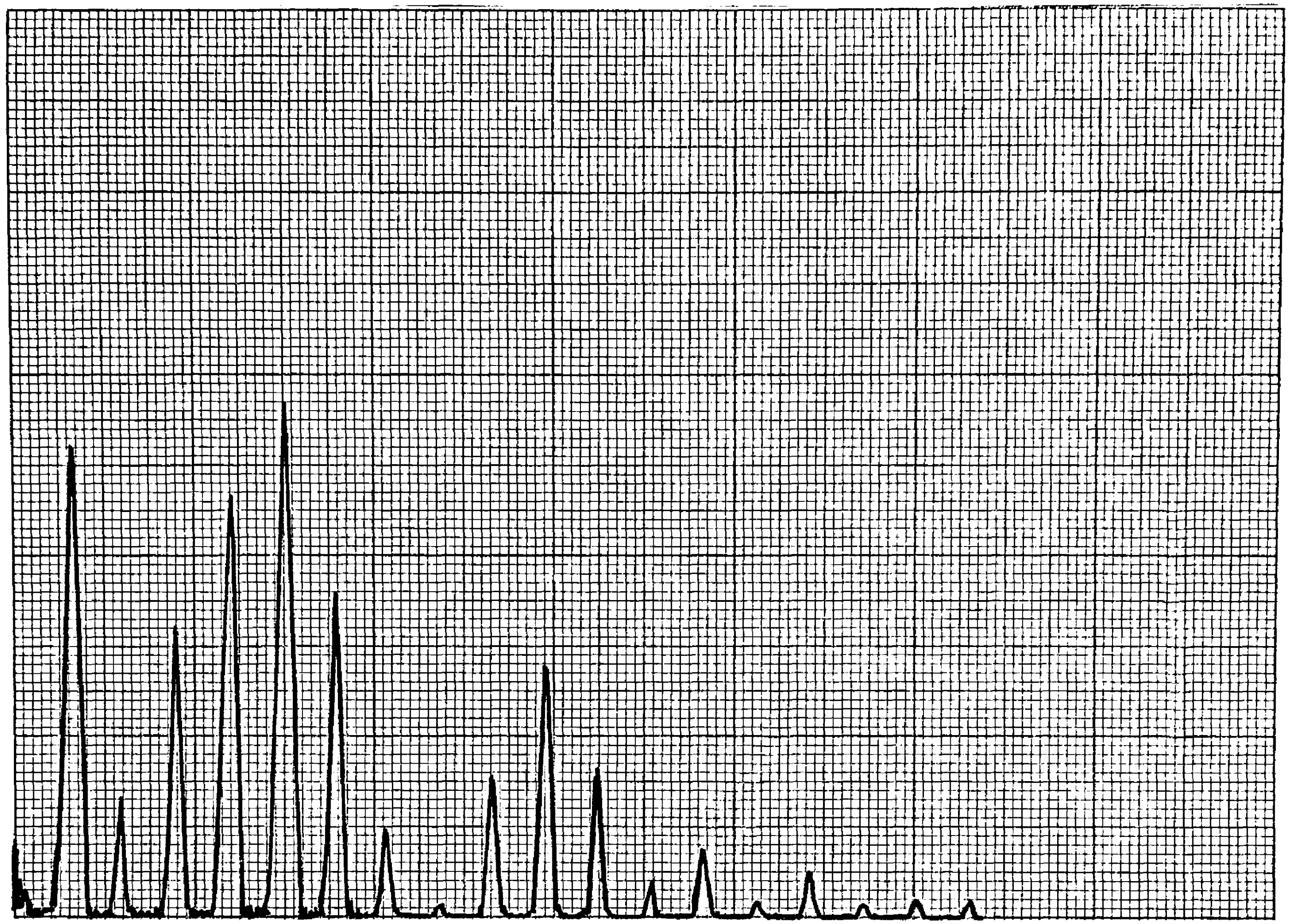
Spectrum Analysis Graph: Group III, Subject Number 7, Pitch f.



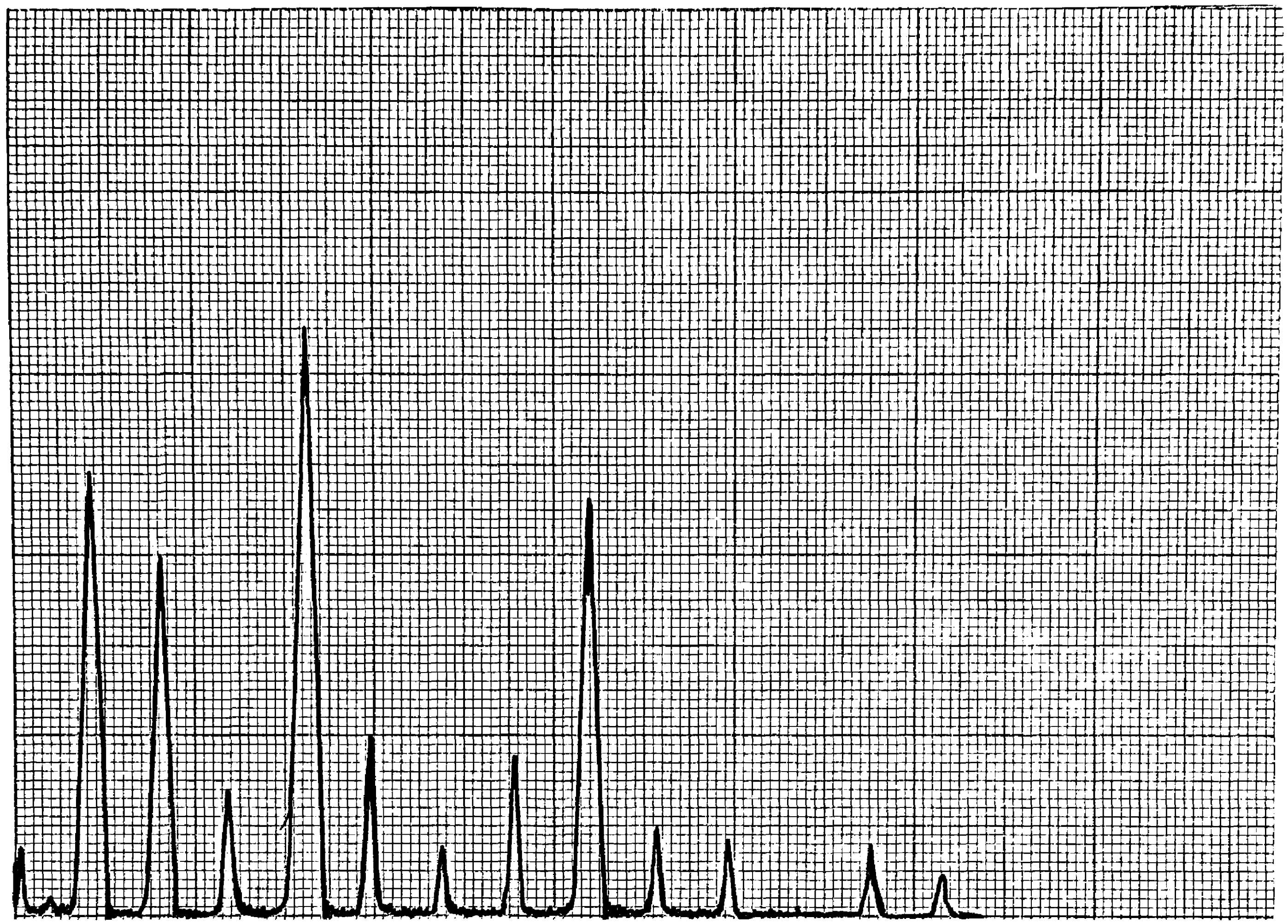
Spectrum Analysis Graph: Group III, Subject Number 7, Pitch b^b.



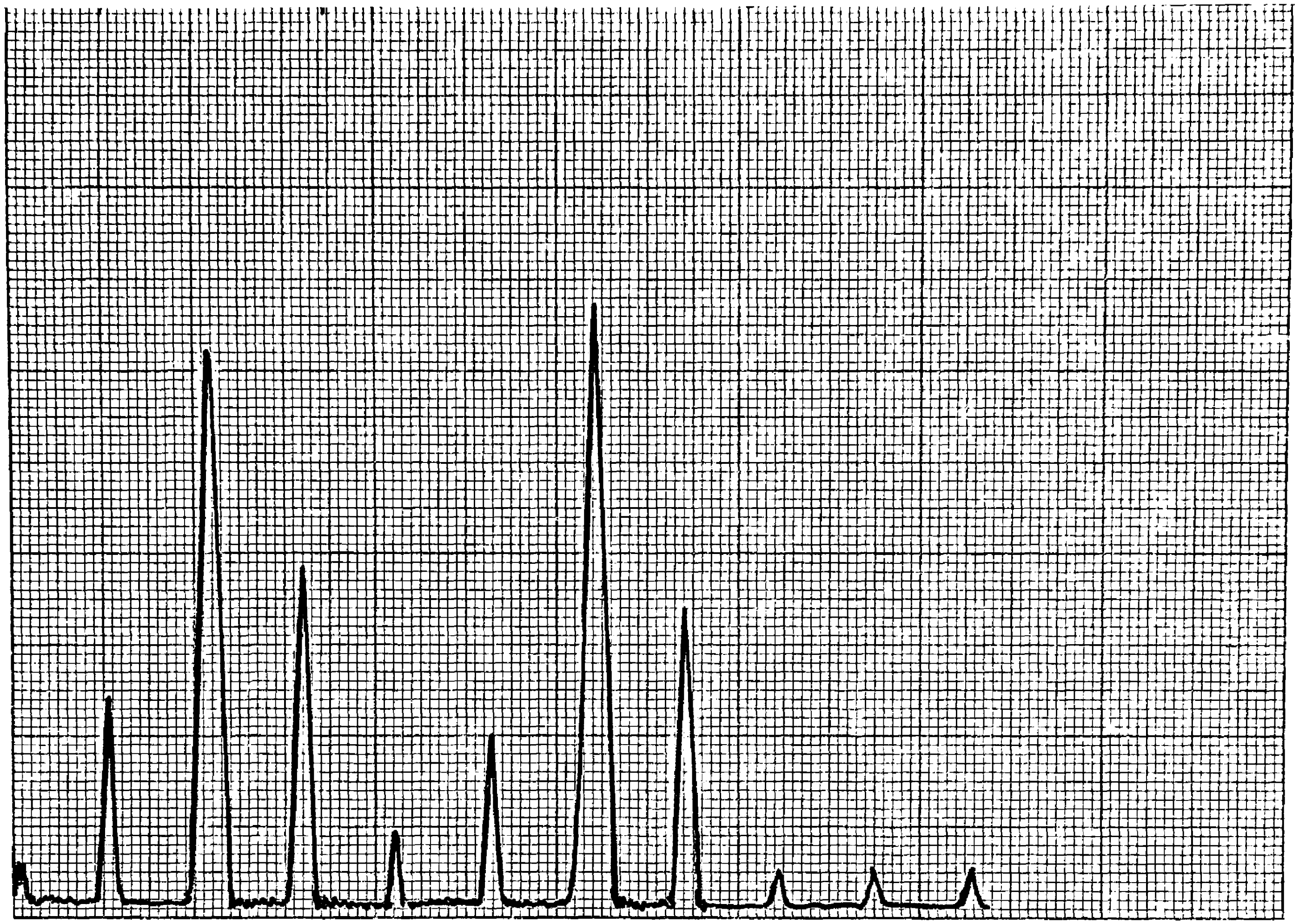
Spectrum Analysis Graph: Group III, Subject Number 7, Pitch e^b.



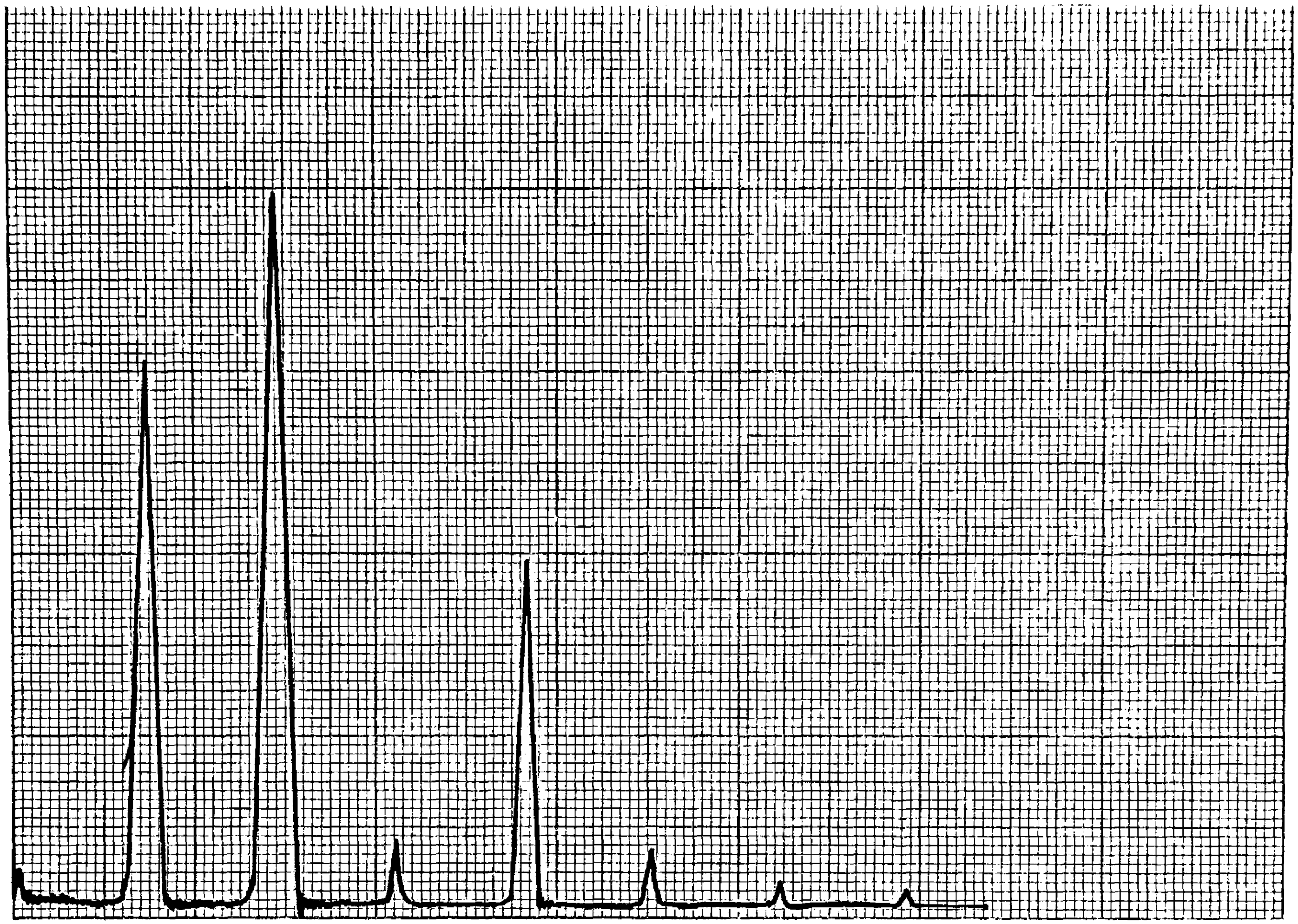
Spectrum Analysis Graph: Group III, Subject Number 8, Pitch d.



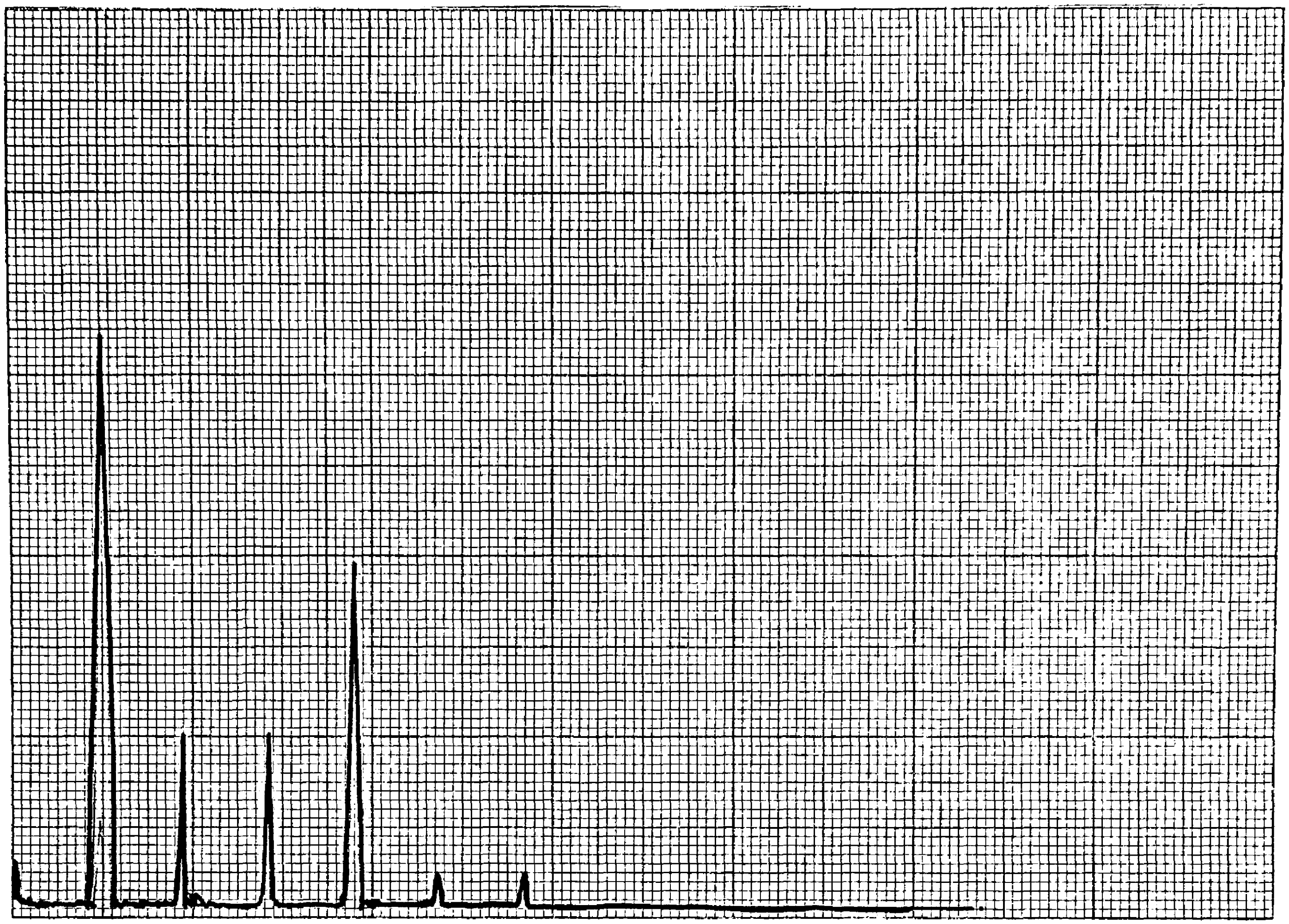
Spectrum Analysis Graph: Group III, Subject Number 8, Pitch g.



Spectrum Analysis Graph: Group III, Subject Number 8, Pitch c.



Spectrum Analysis Graph: Group III, Subject Number 8, Pitch f.



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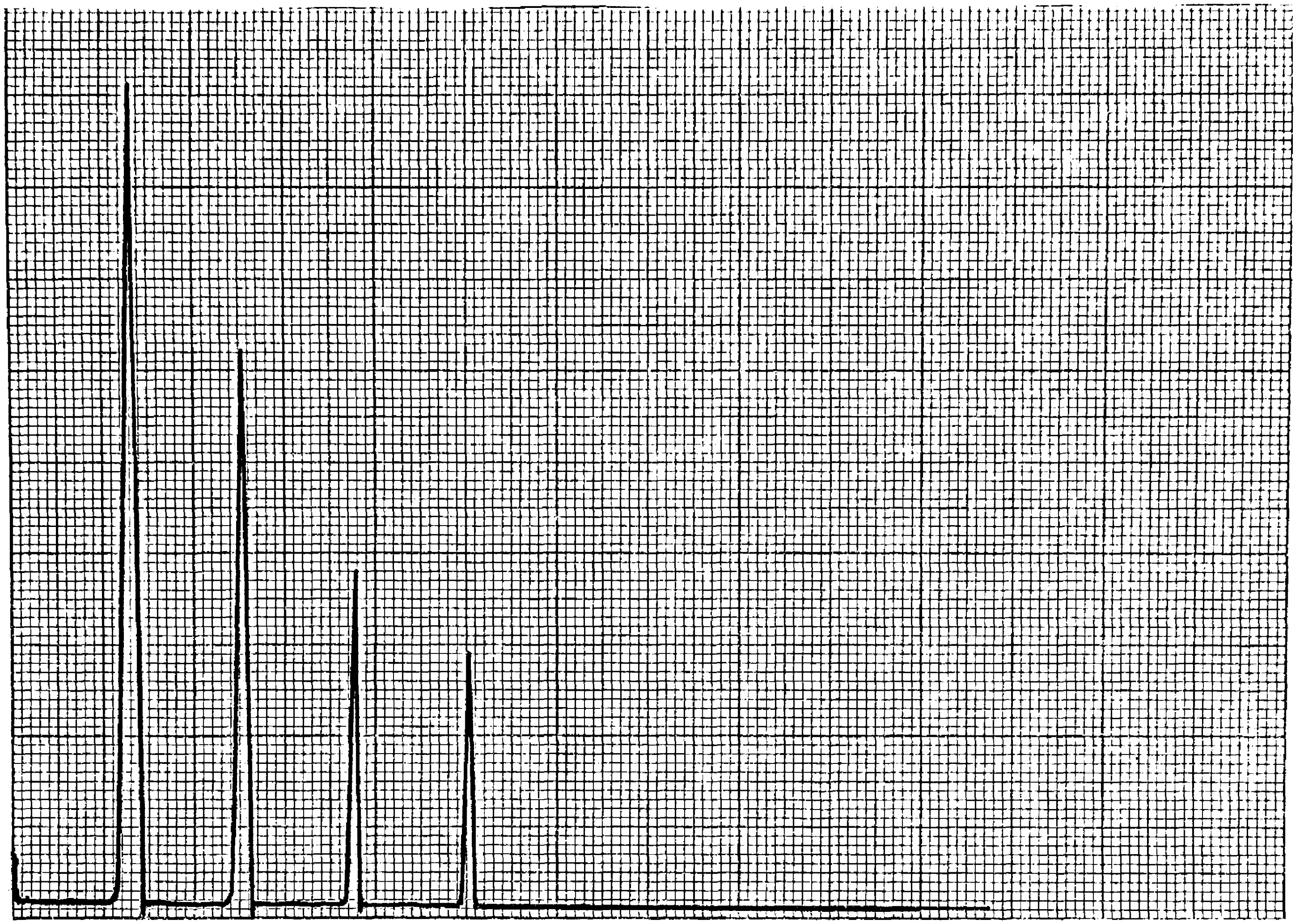

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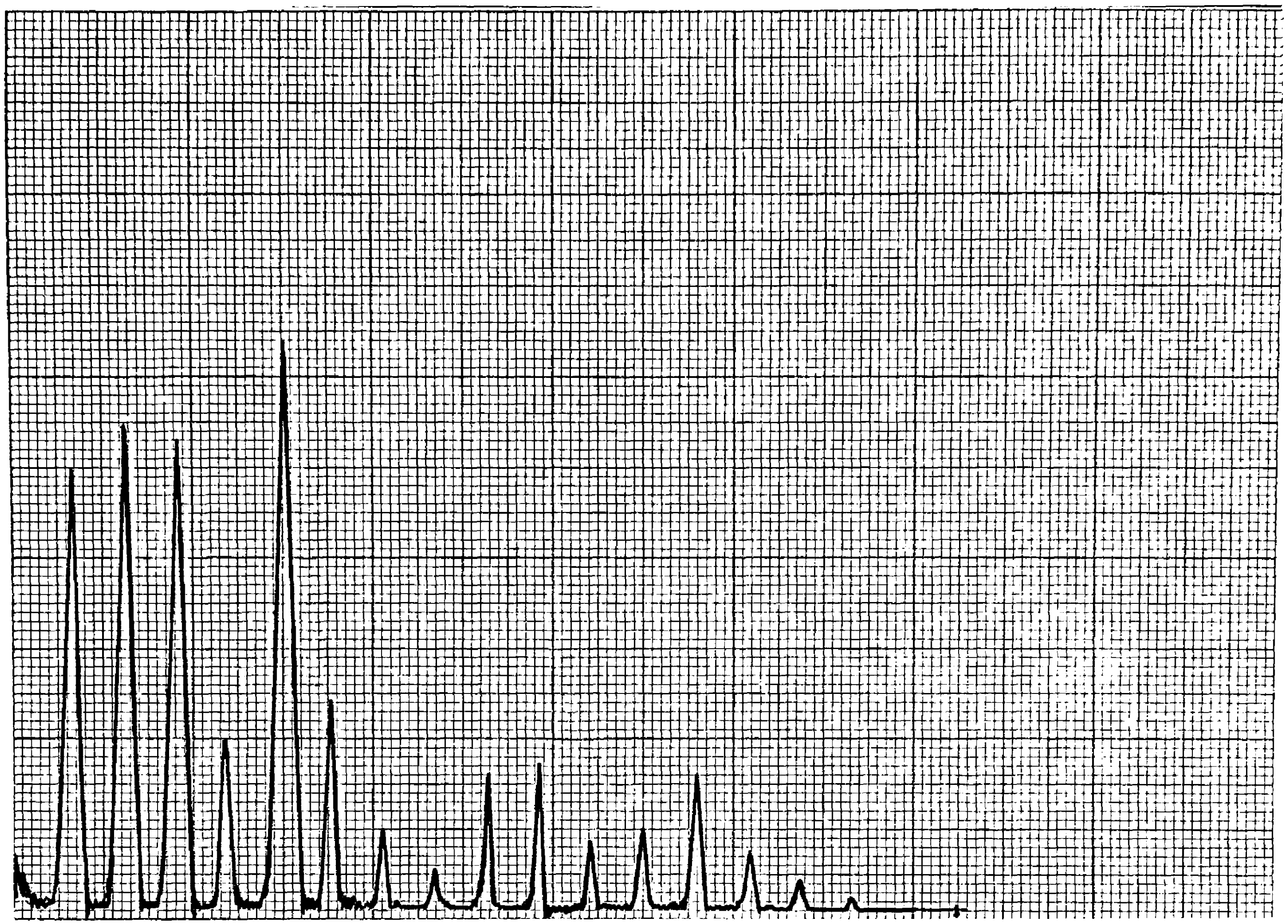
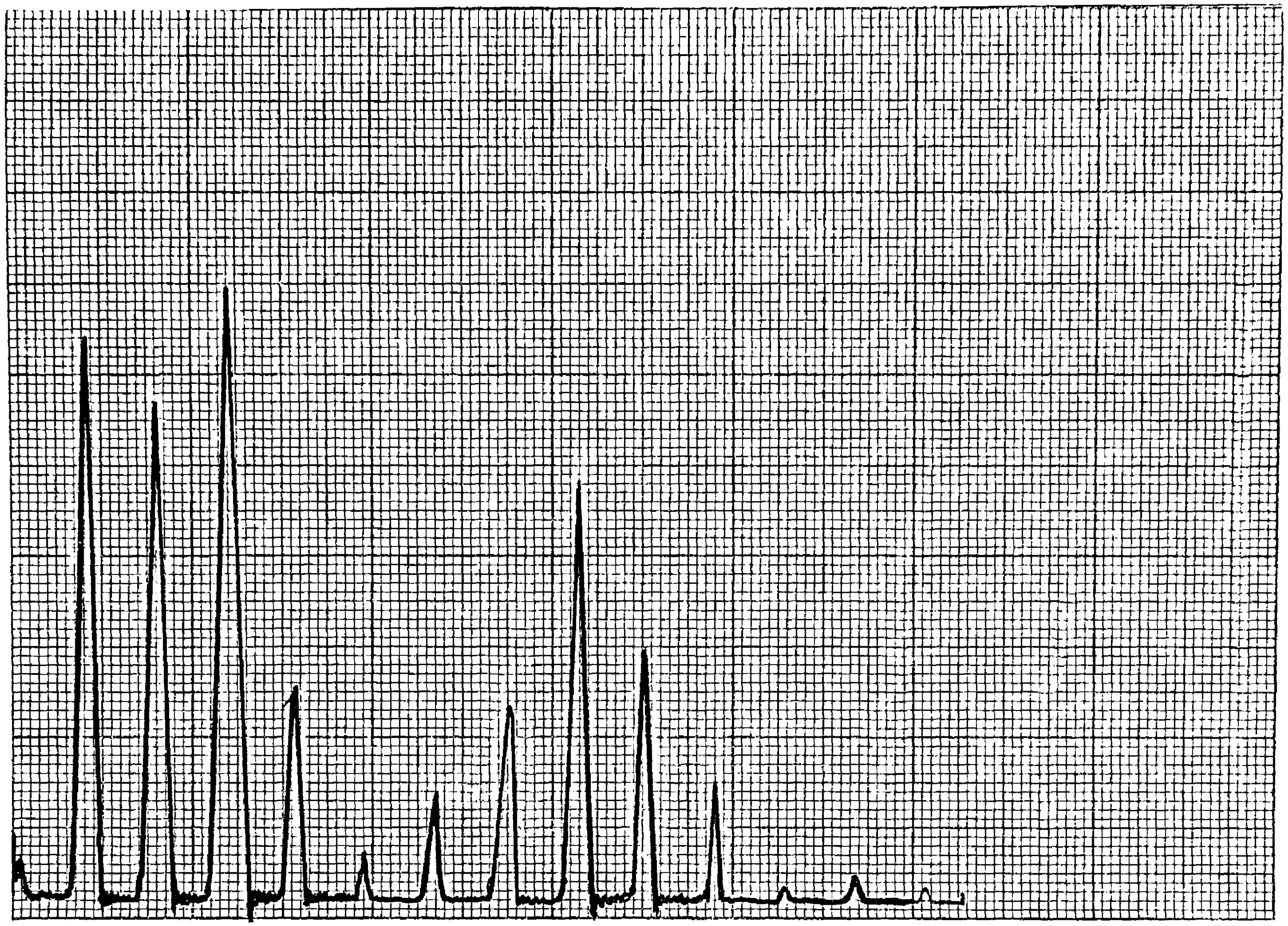
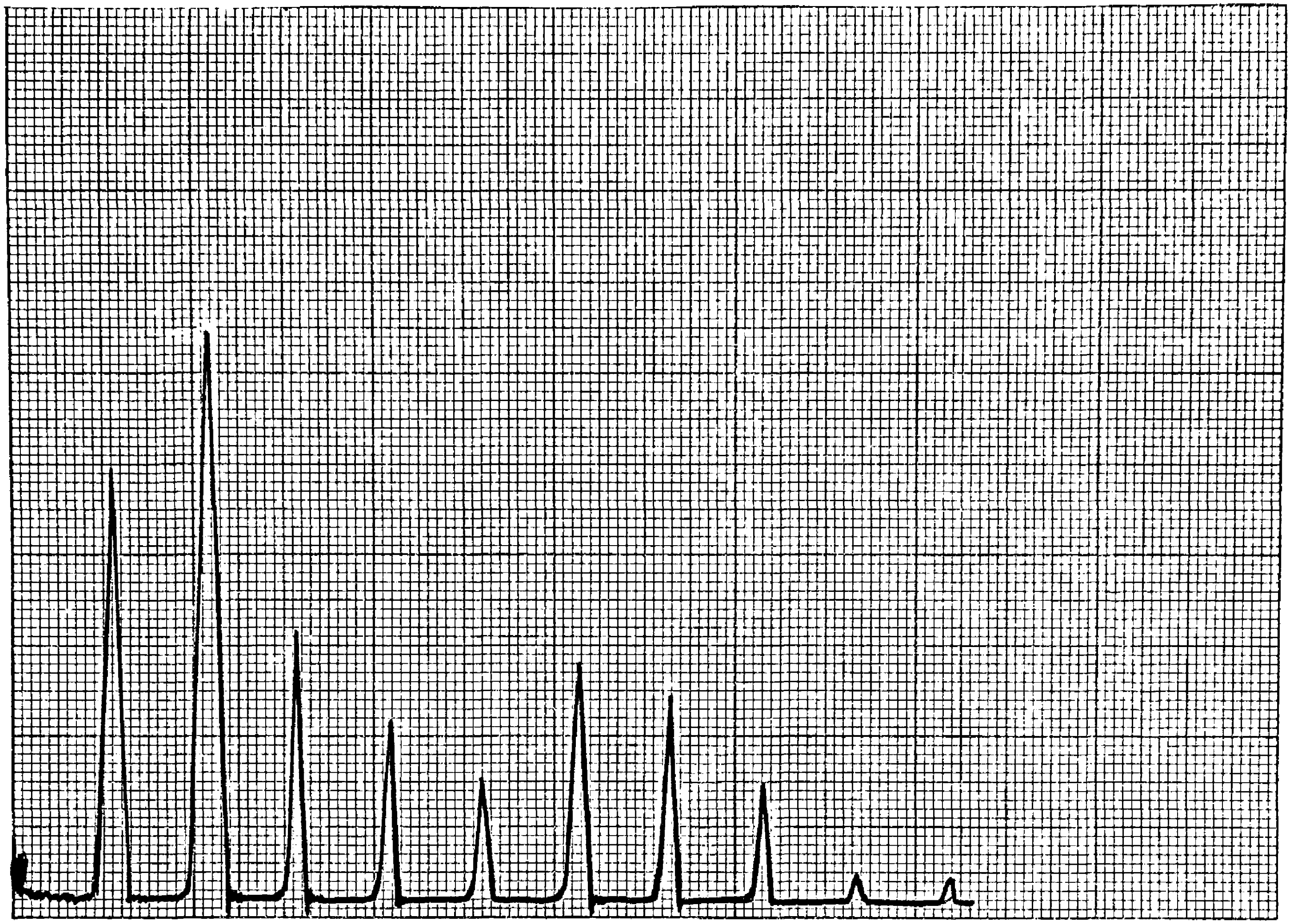


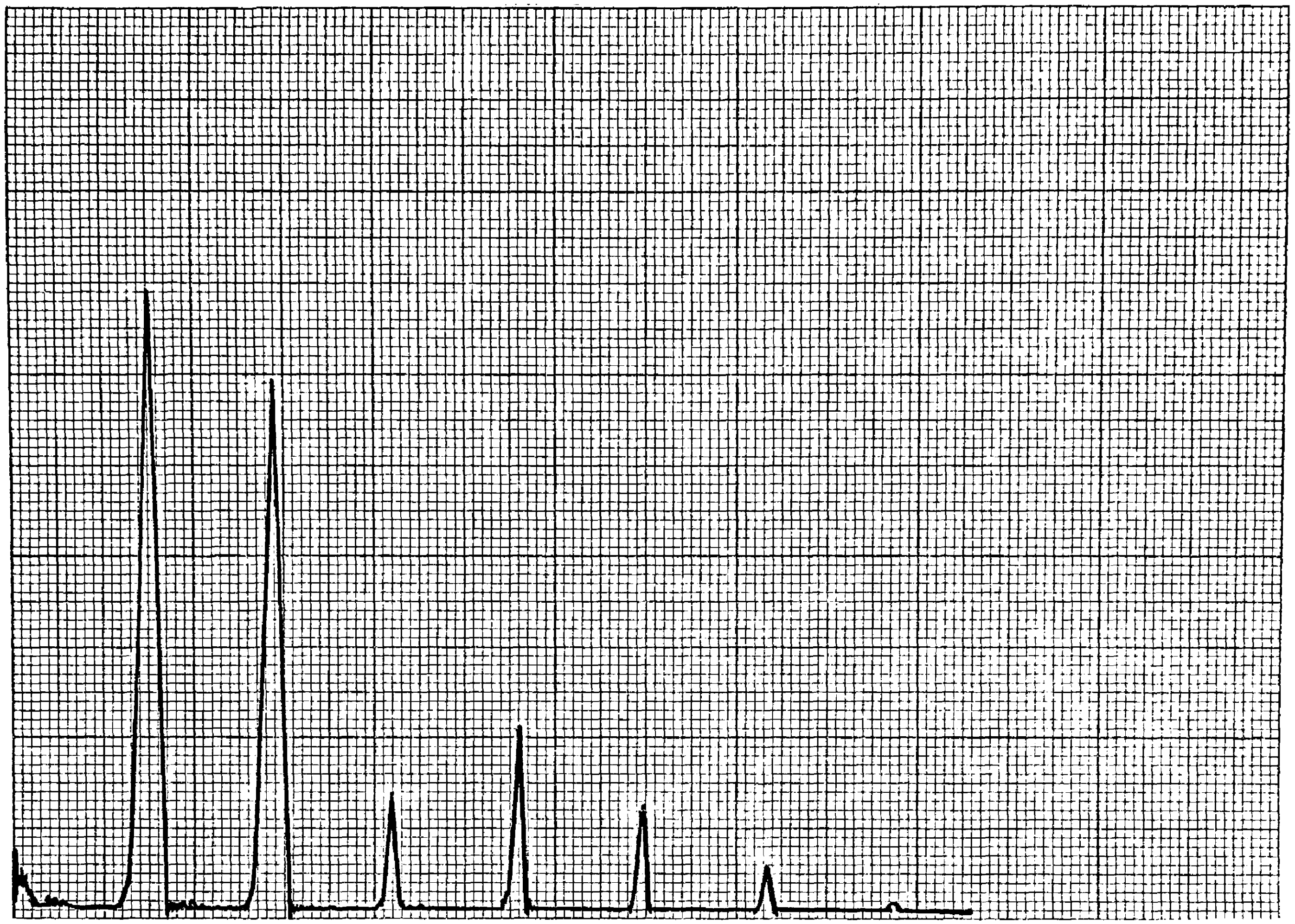
Spectrum Analysis Graph: Group III, Subject Number 9, Pitch d.



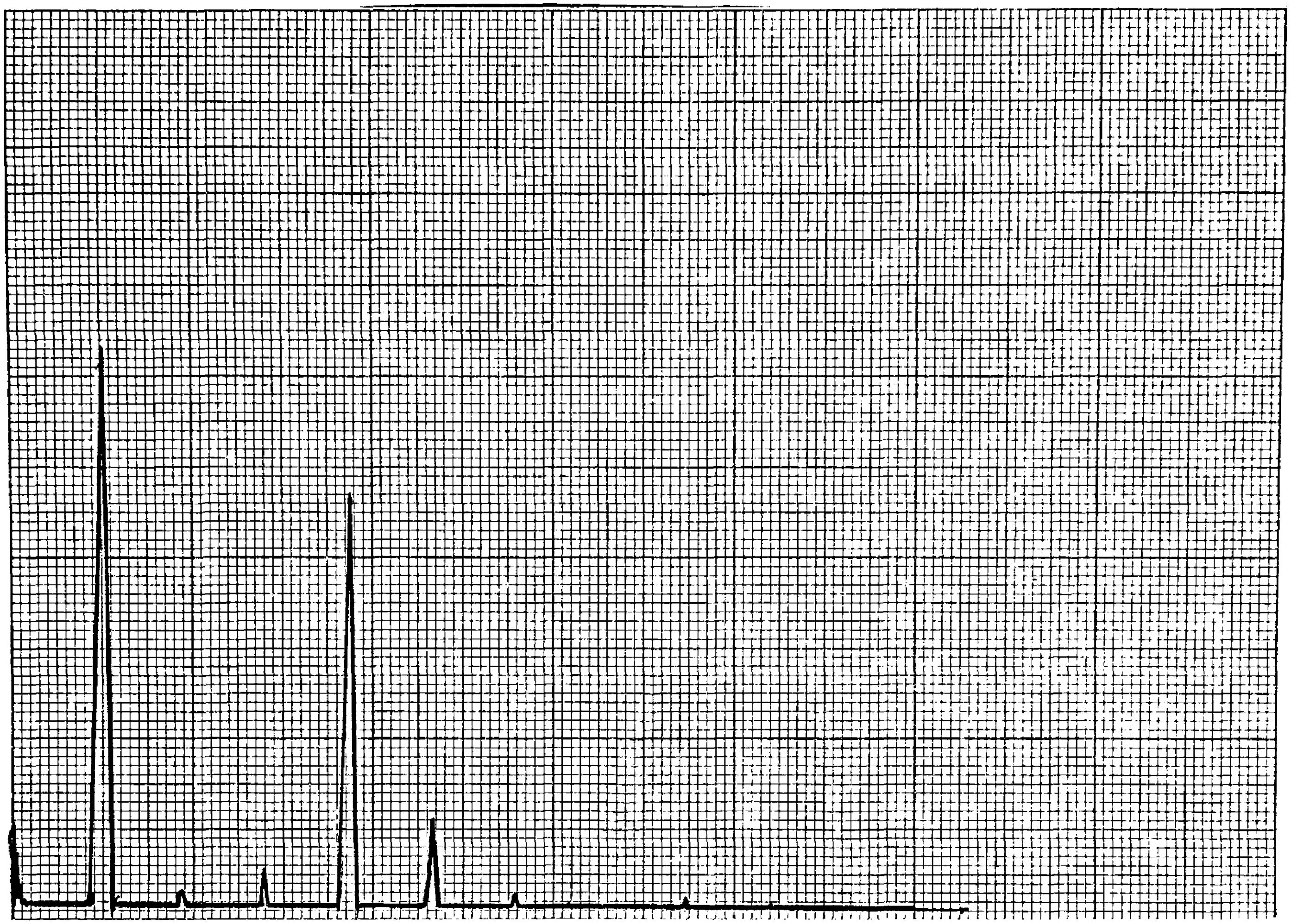
Spectrum Analysis Graph: Group III, Subject Number 9, Pitch g.



Spectrum Analysis Graph: Group III, Subject Number 9, Pitch c.



Spectrum Analysis Graph: Group III, Subject Number 9, Pitch f.



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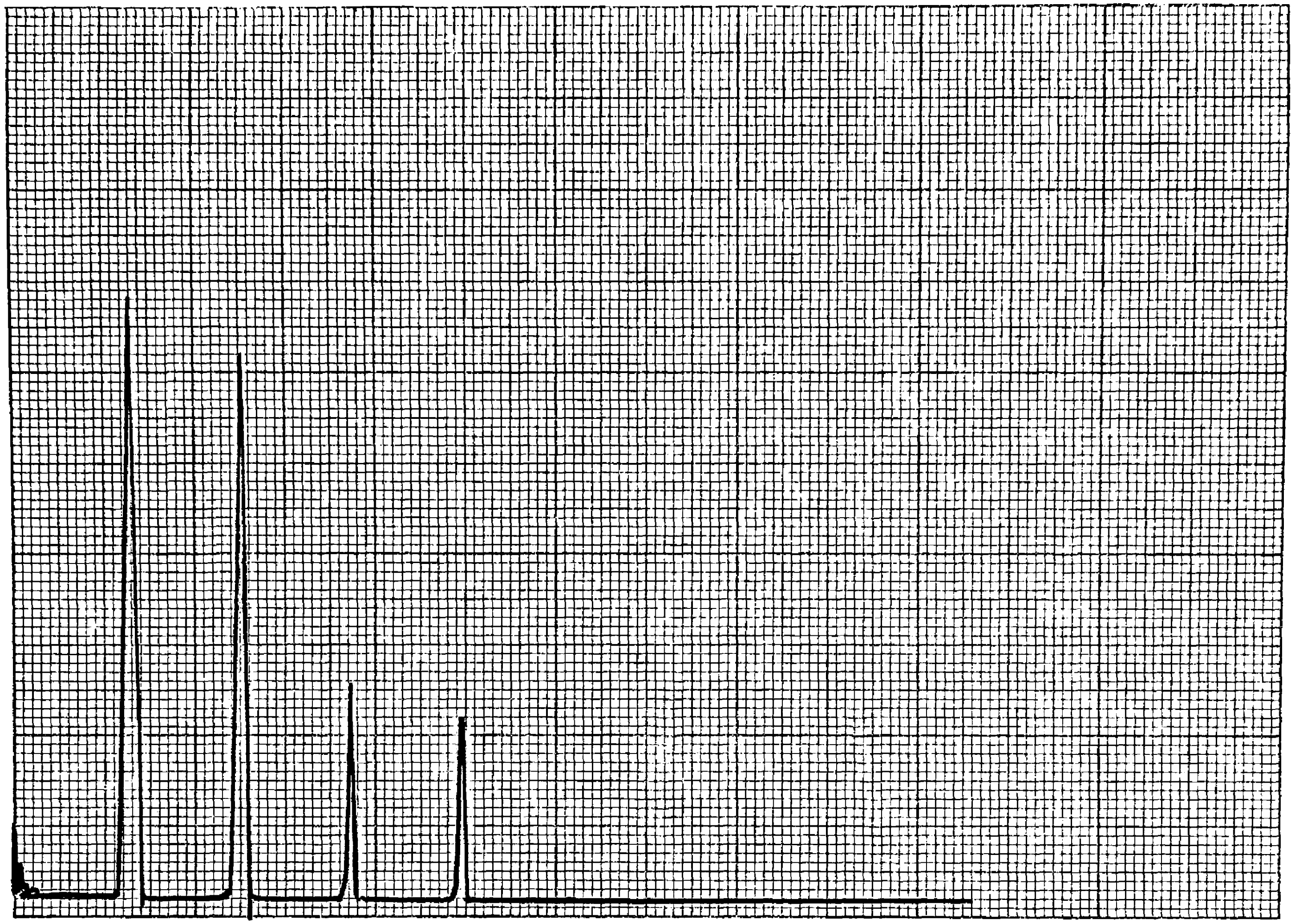
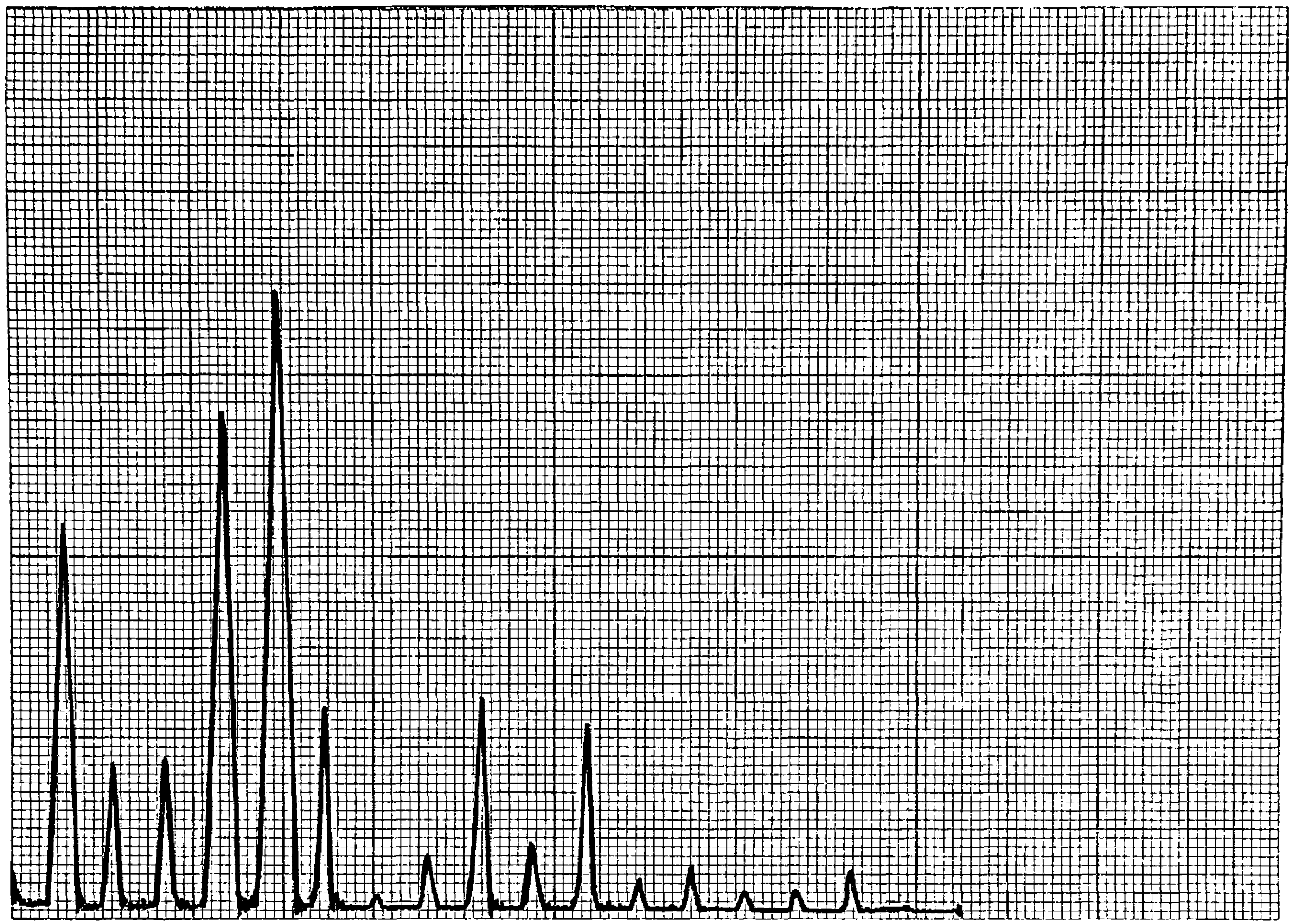
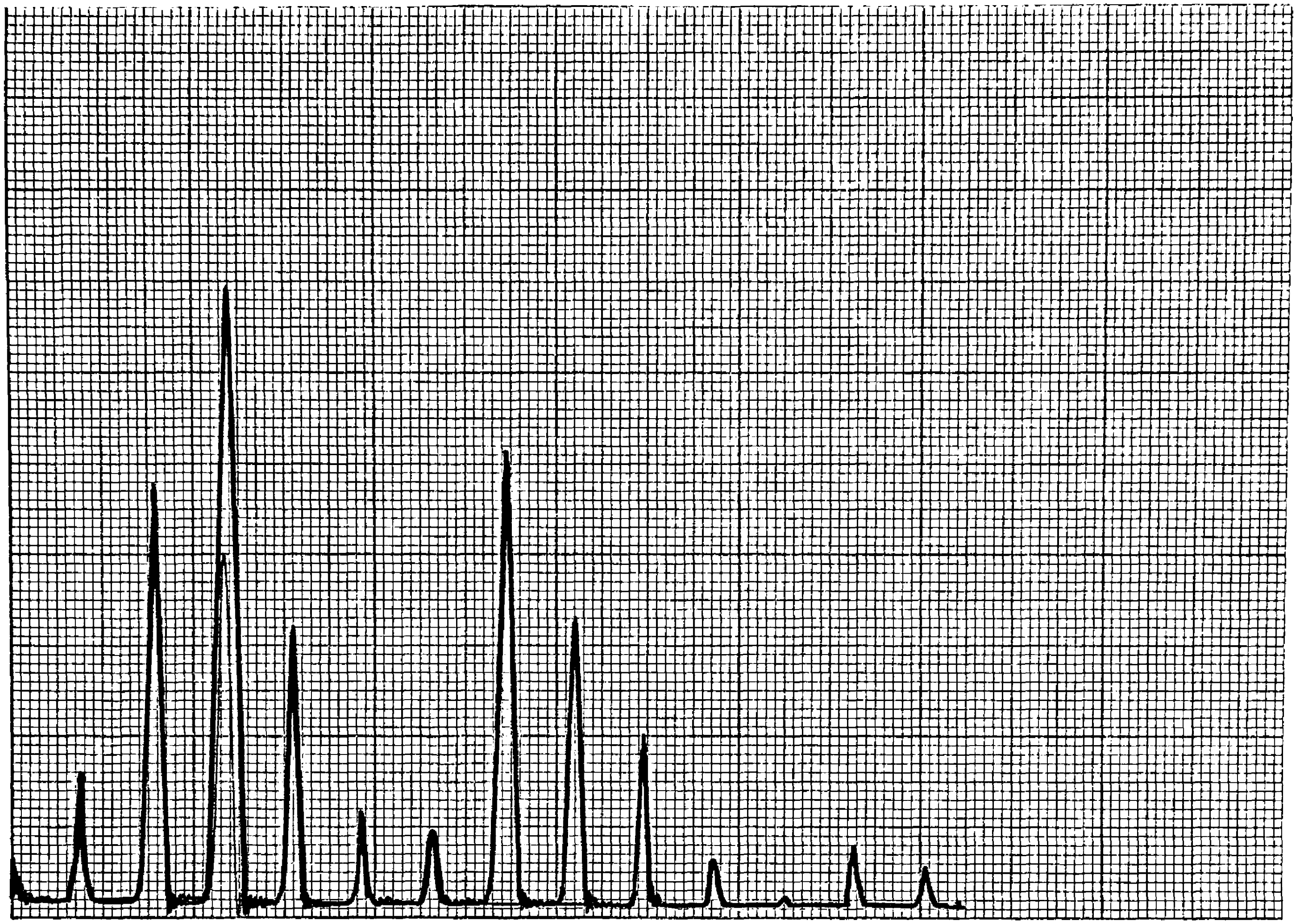


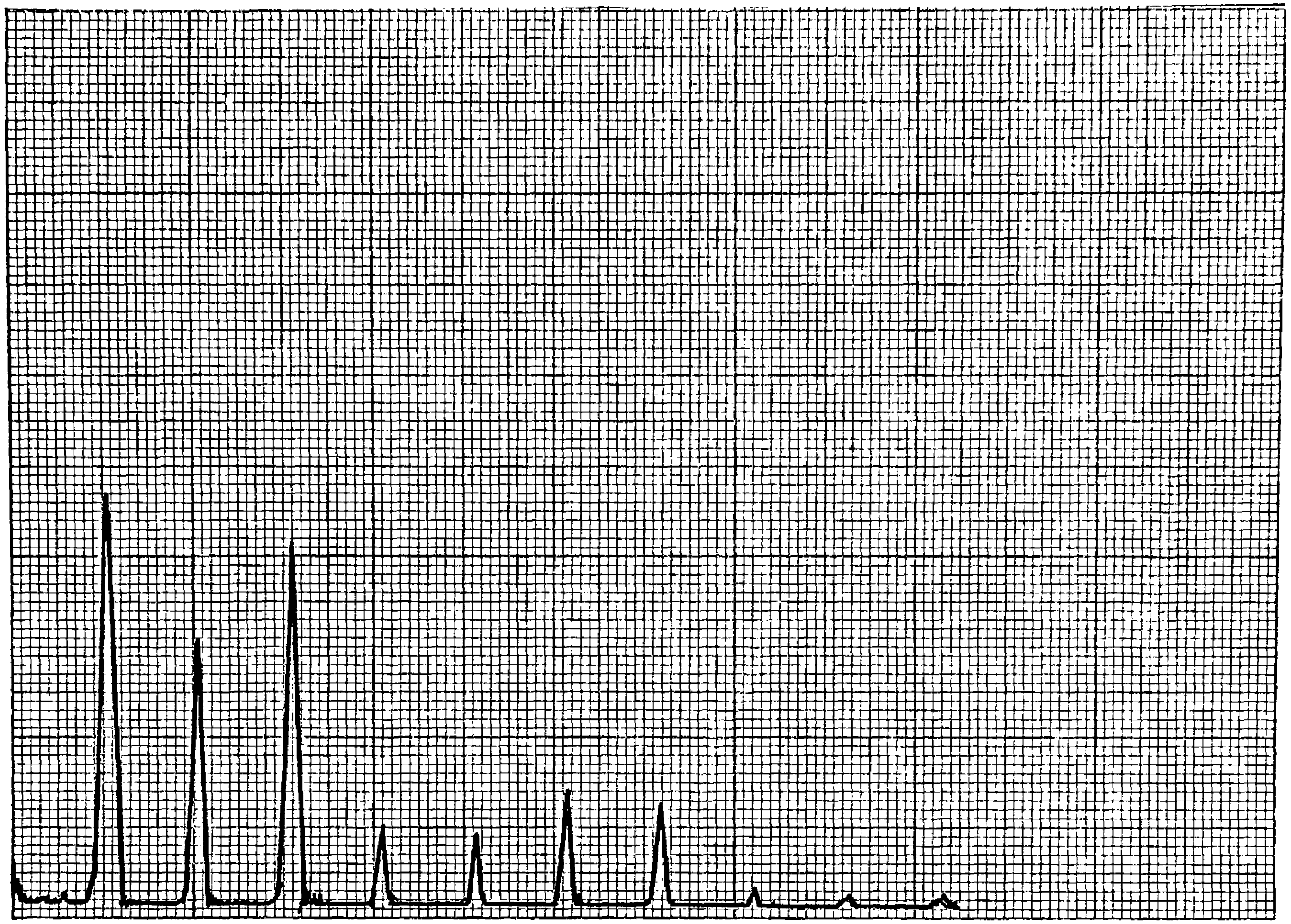
Spectrum Analysis Graph: Group III, Subject Number 9, Pitch e^{b}.



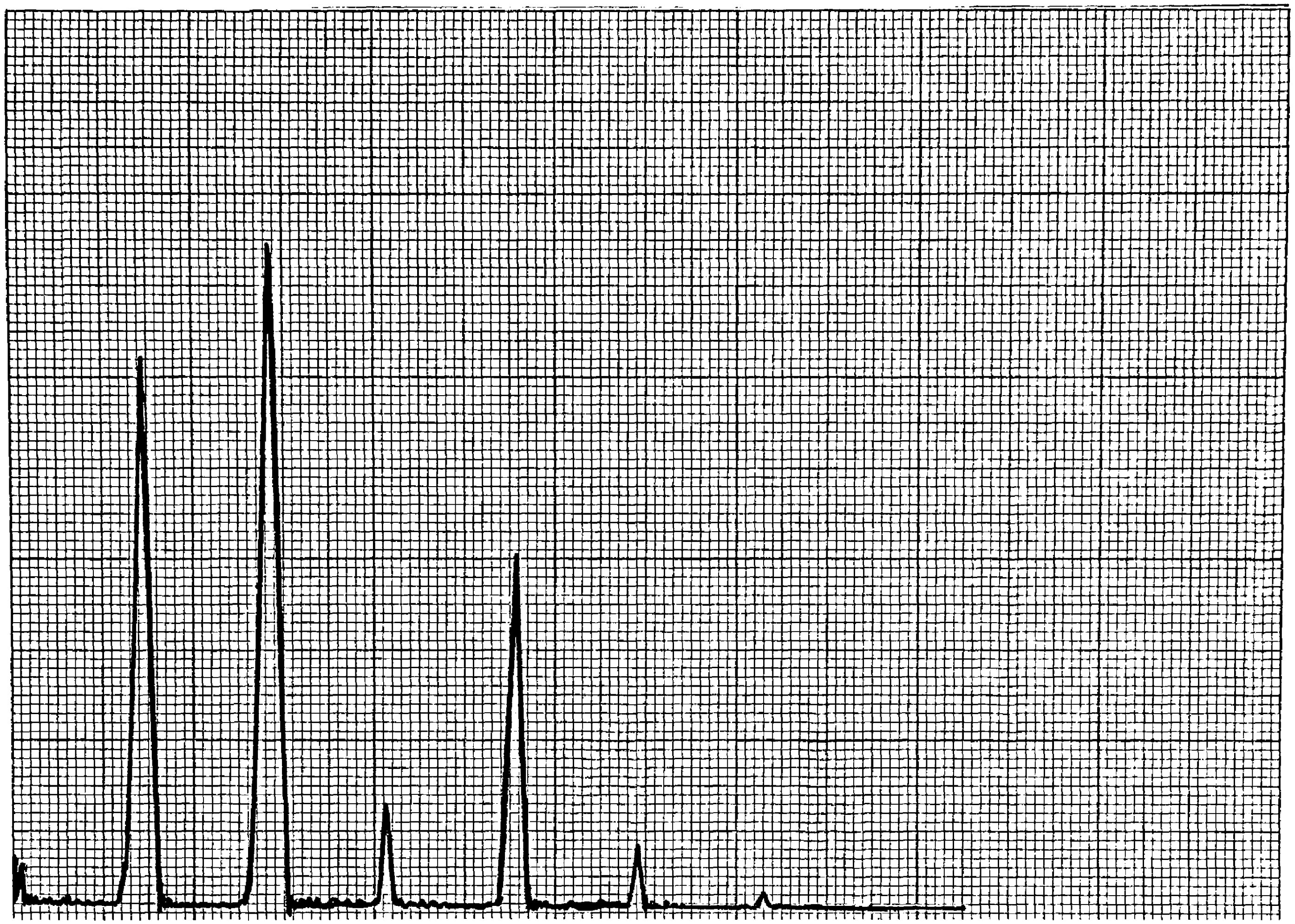
Spectrum Analysis Graph: Group III, Subject Number 19, Pitch d.



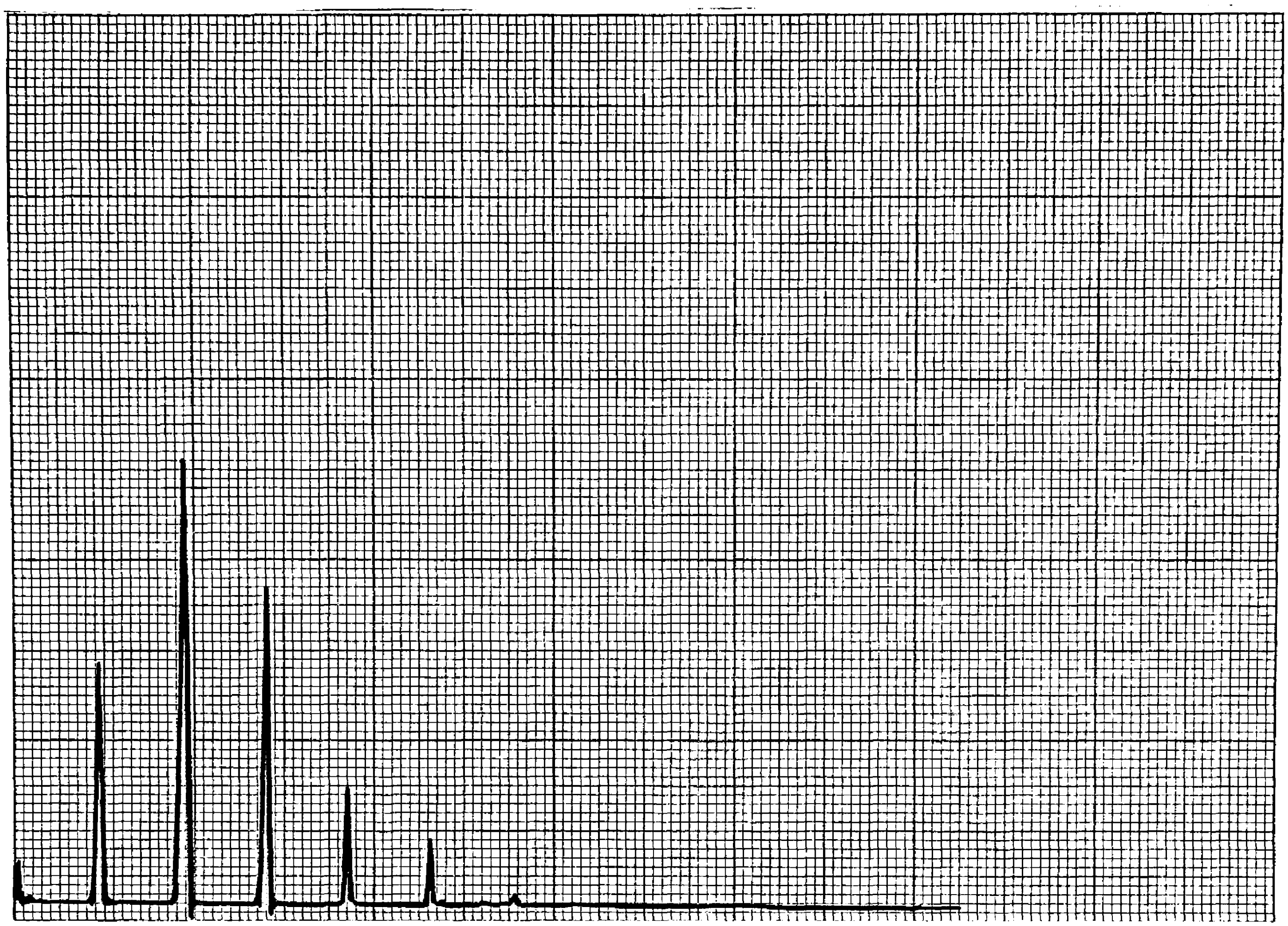
Spectrum Analysis Graph: Group III, Subject Number 19, Pitch g.



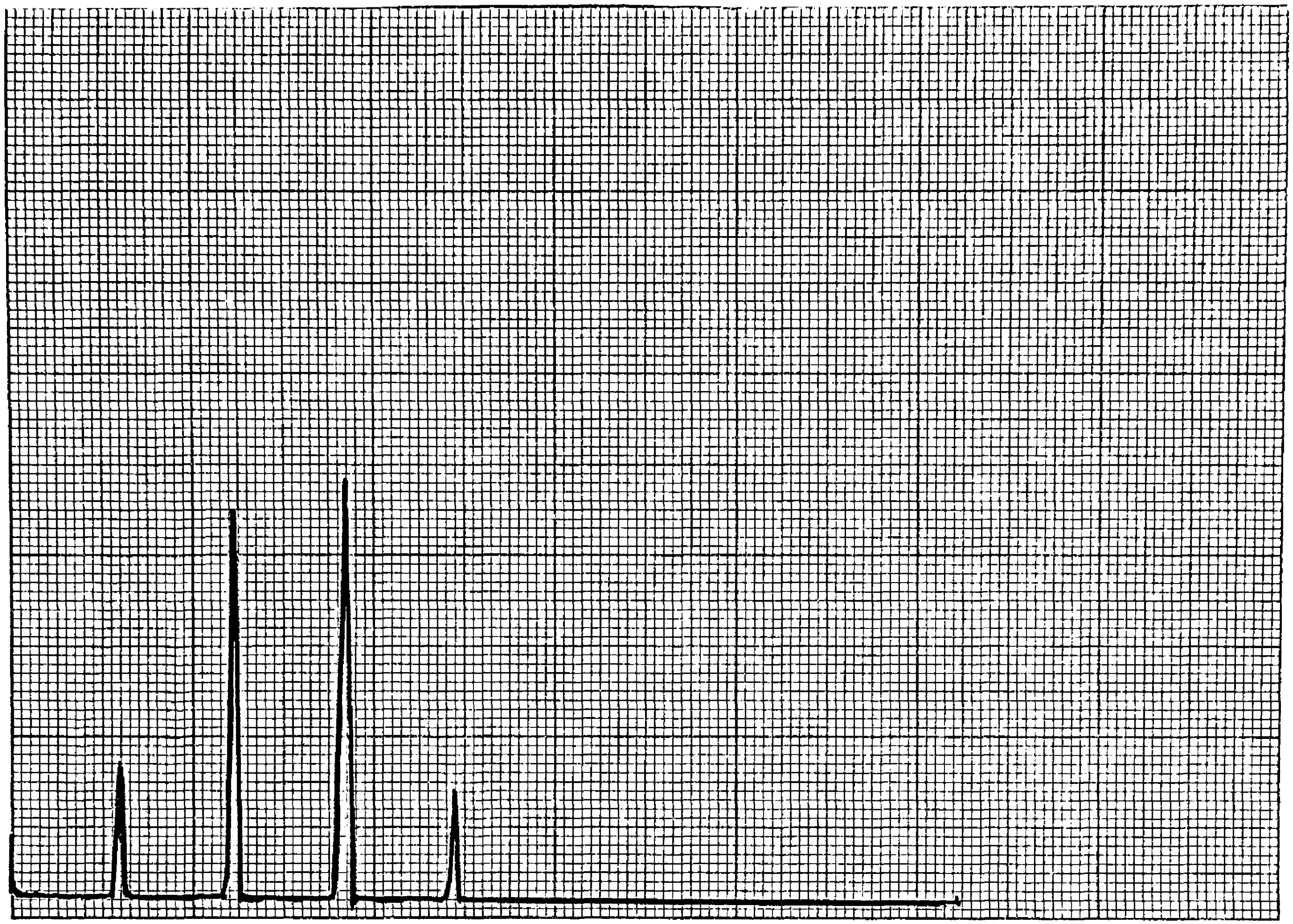
Spectrum Analysis Graph: Group III, Subject Number 19, Pitch c.



Spectrum Analysis Graph: Group III, Subject Number 19, Pitch f.



Spectrum Analysis Graph: Group III, Subject Number 19, Pitch b^{b}.

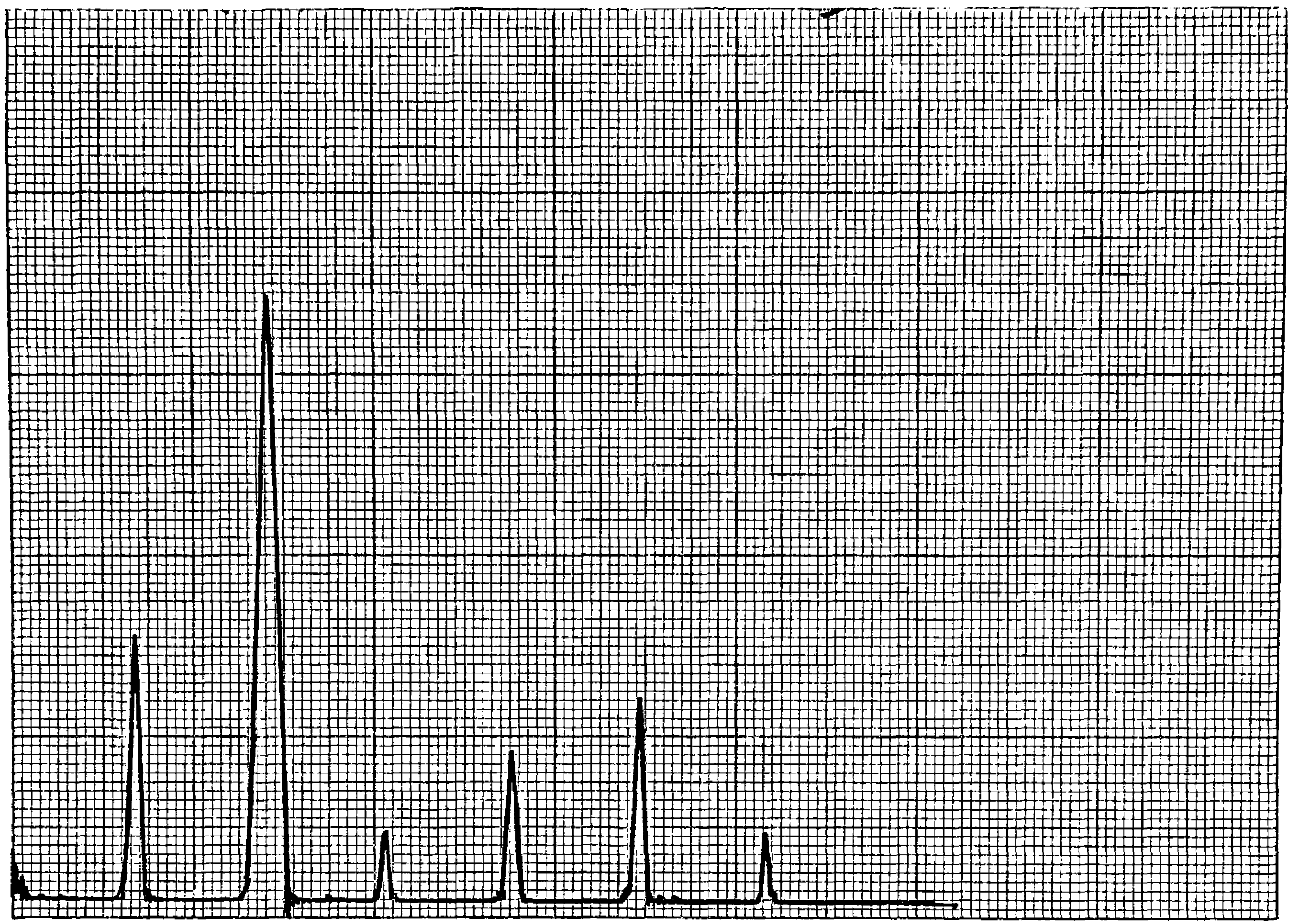


Spectrum Analysis Graph: Group III, Subject Number 19, Pitch e^{b}.

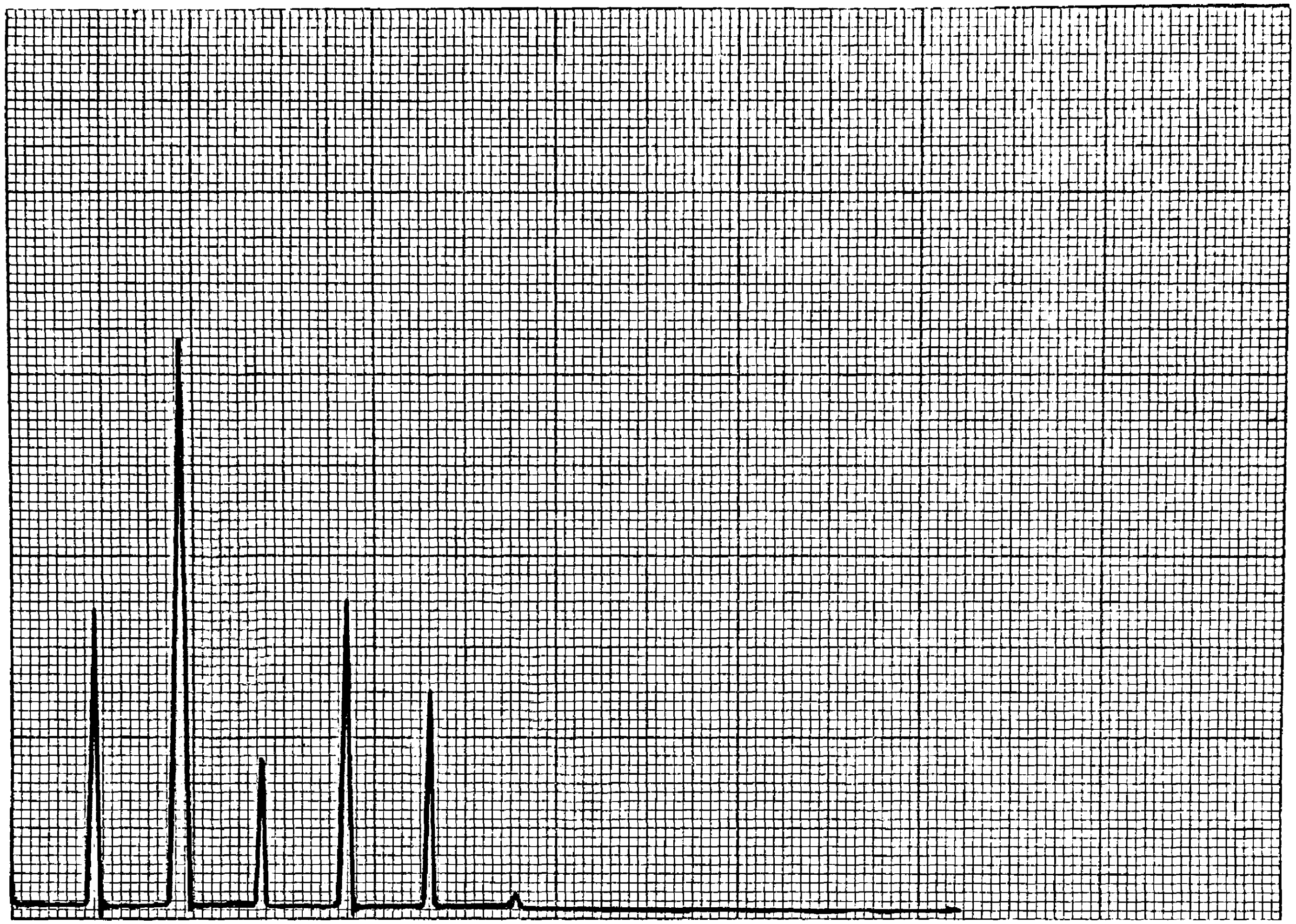
Spectrum Analysis Graph: Group III, Subject Number 20, Pitch d.

Spectrum Analysis Graph: Group III, Subject Number 20, Pitch g.

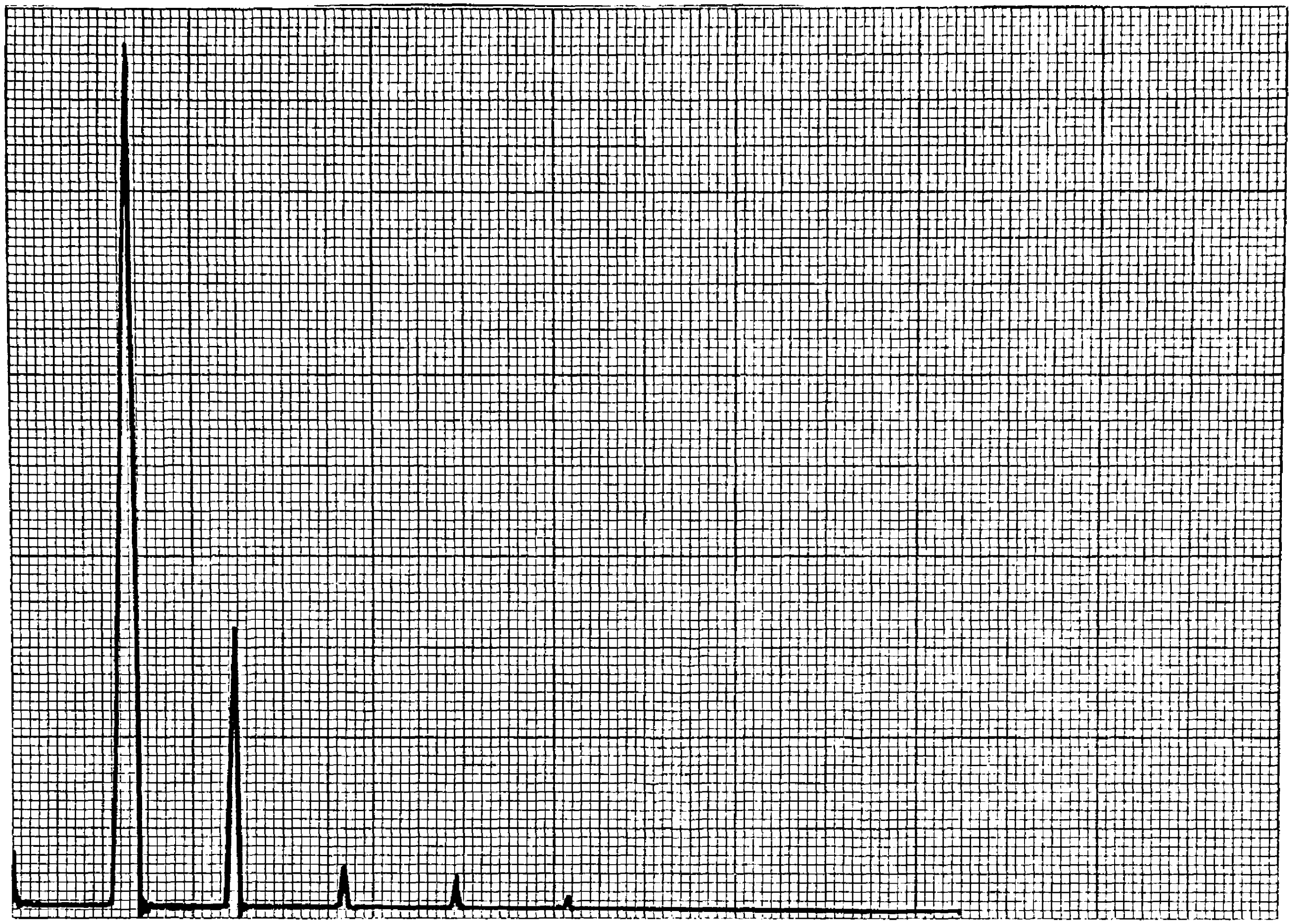
Spectrum Analysis Graph: Group III, Subject Number 20, Pitch c.



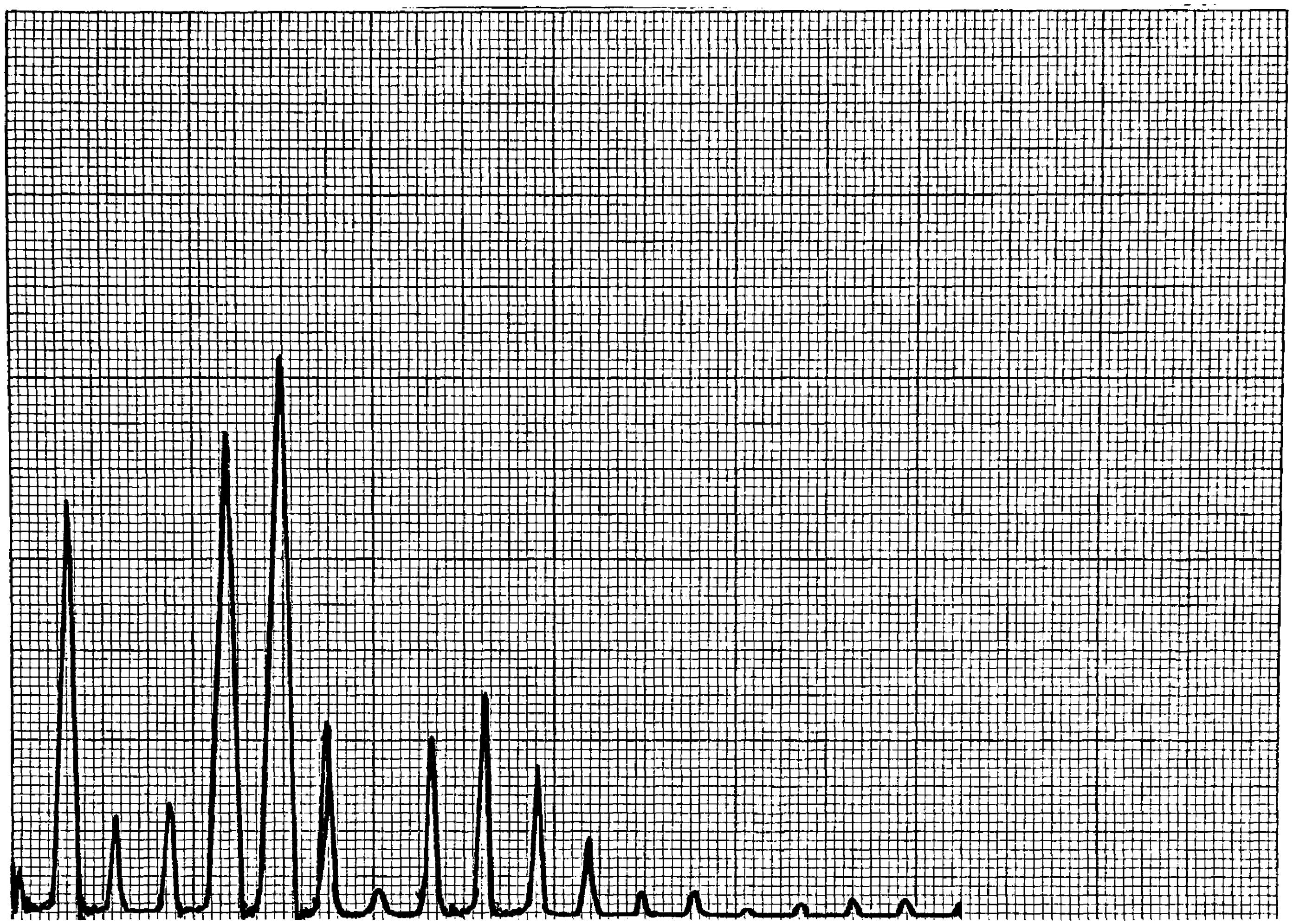
Spectrum Analysis Graph: Group III, Subject Number 20, Pitch f.



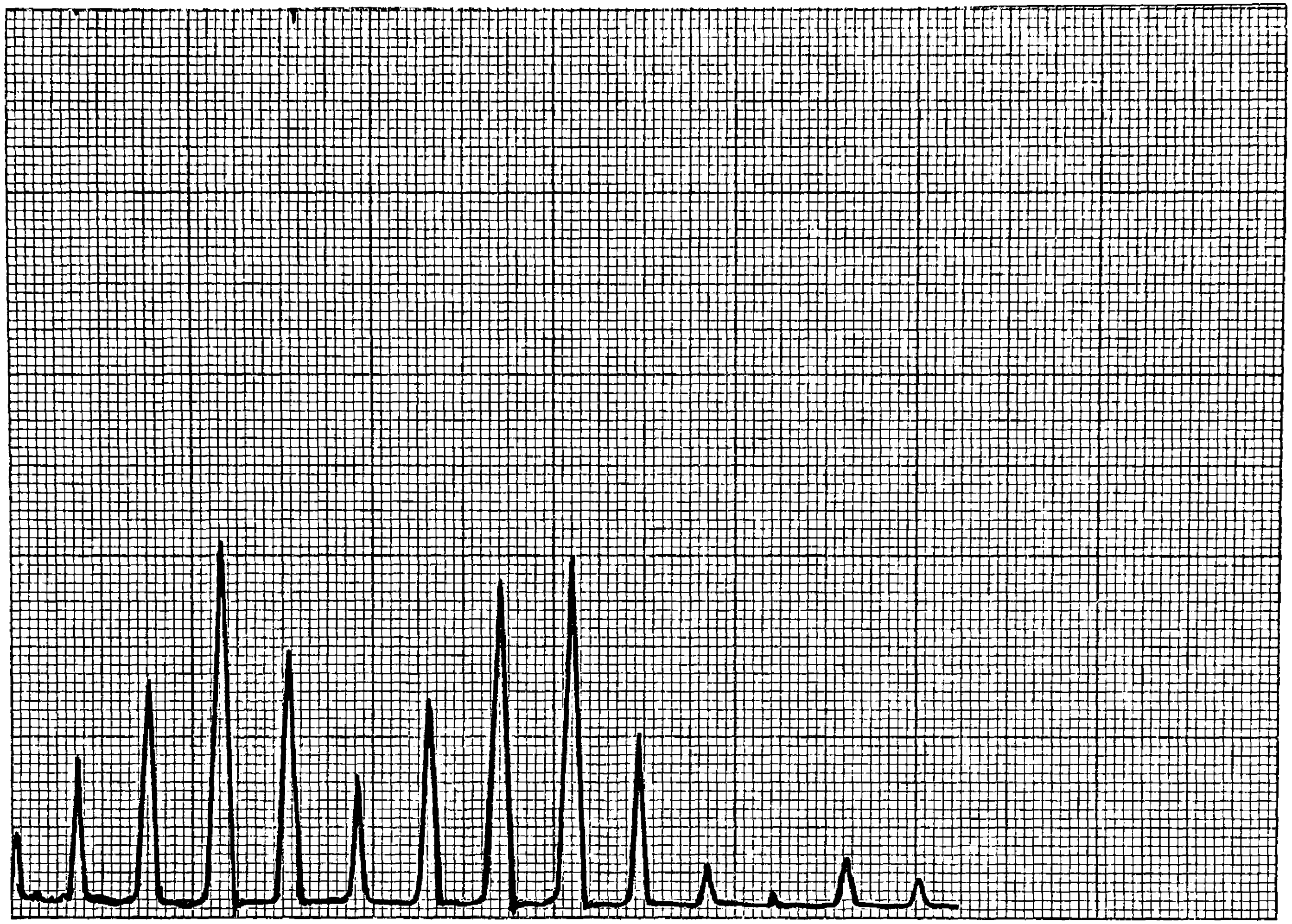
Spectrum Analysis Graph: Group III, Subject Number 20, Pitch b^b.



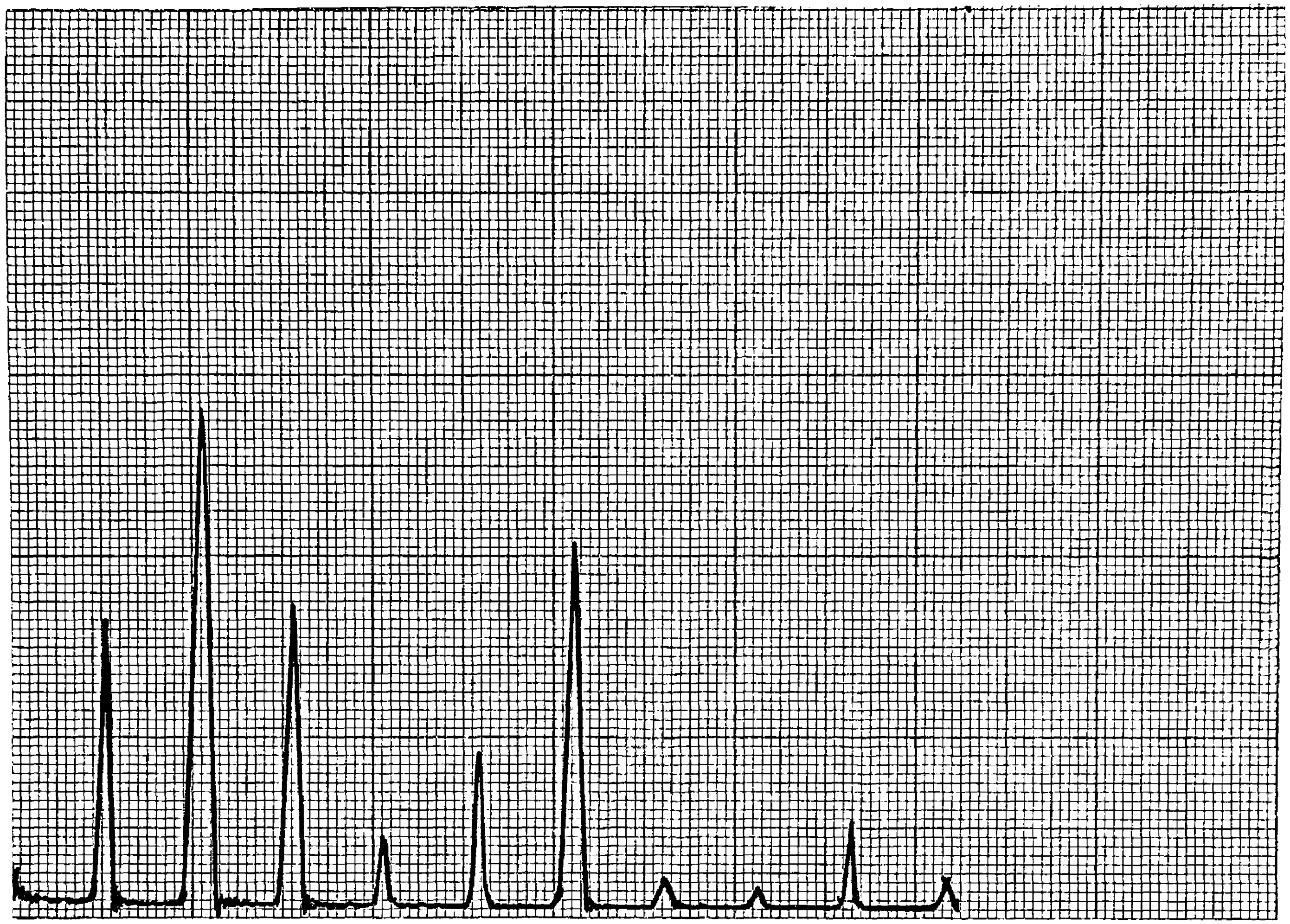
Spectrum Analysis Graph: Group III, Subject Number 20, Pitch e^{b}.



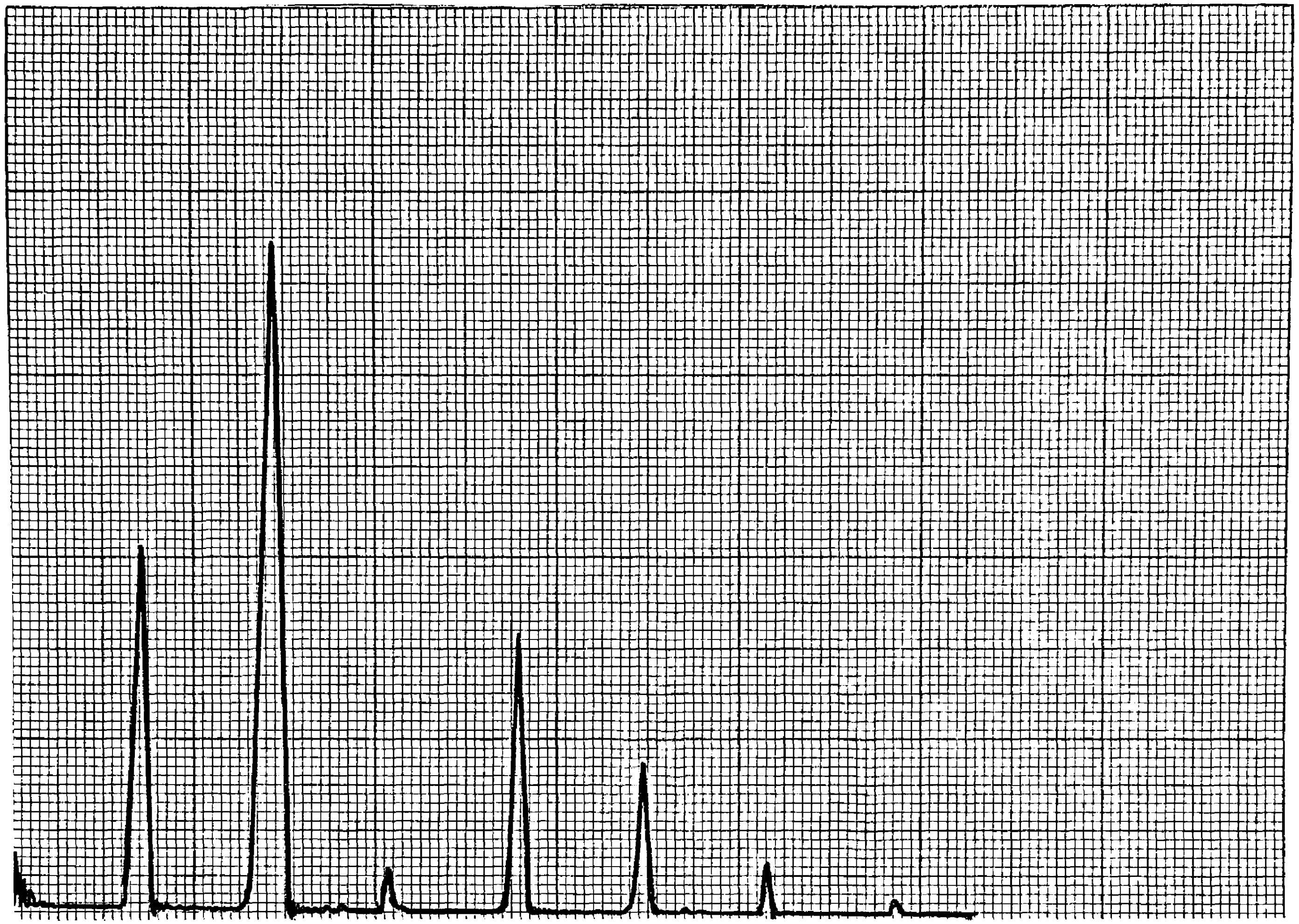
Spectrum Analysis Graph: Group III, Subject Number 21, Pitch d.



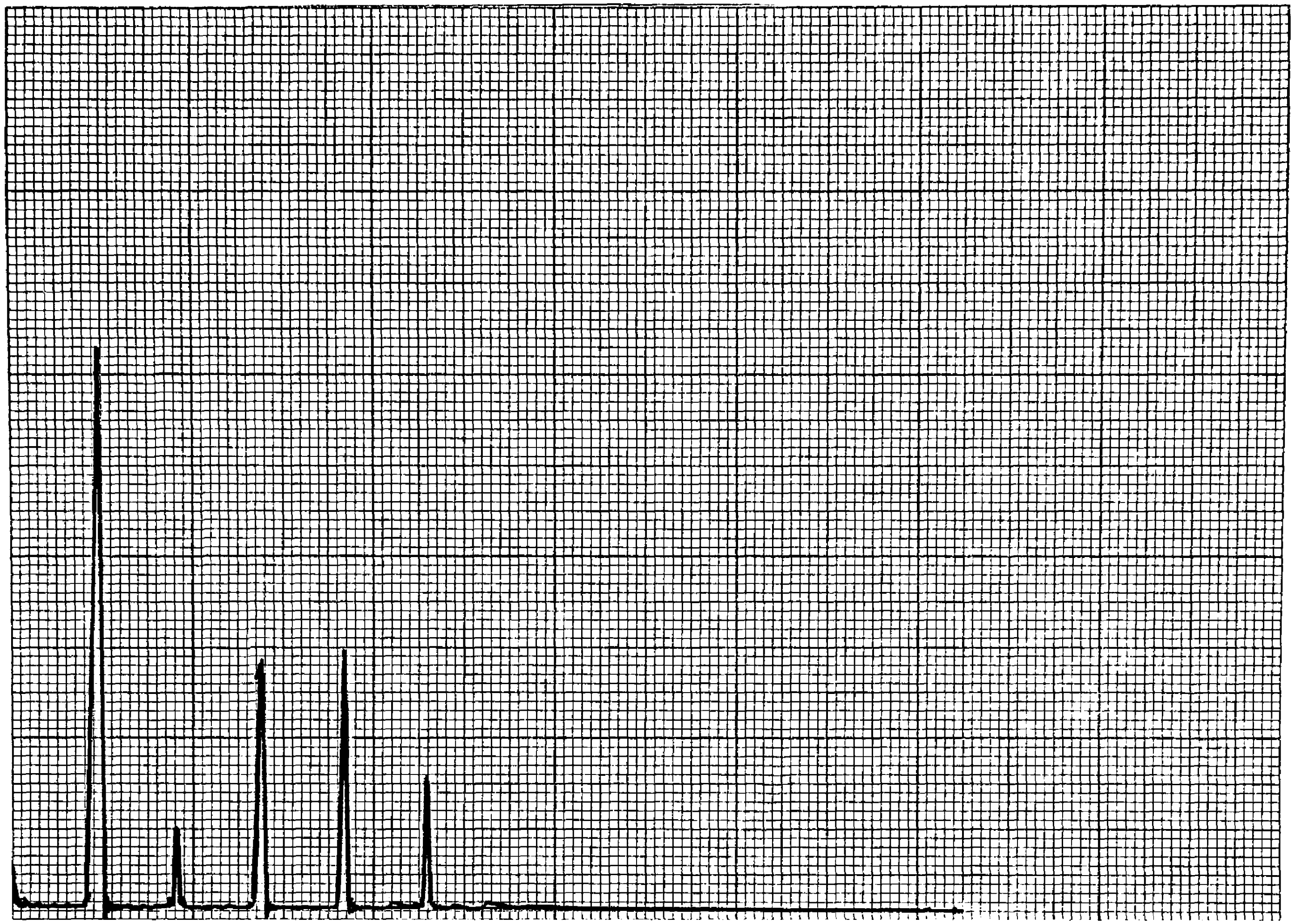
Spectrum Analysis Graph: Group III, Subject Number 21, Pitch g.



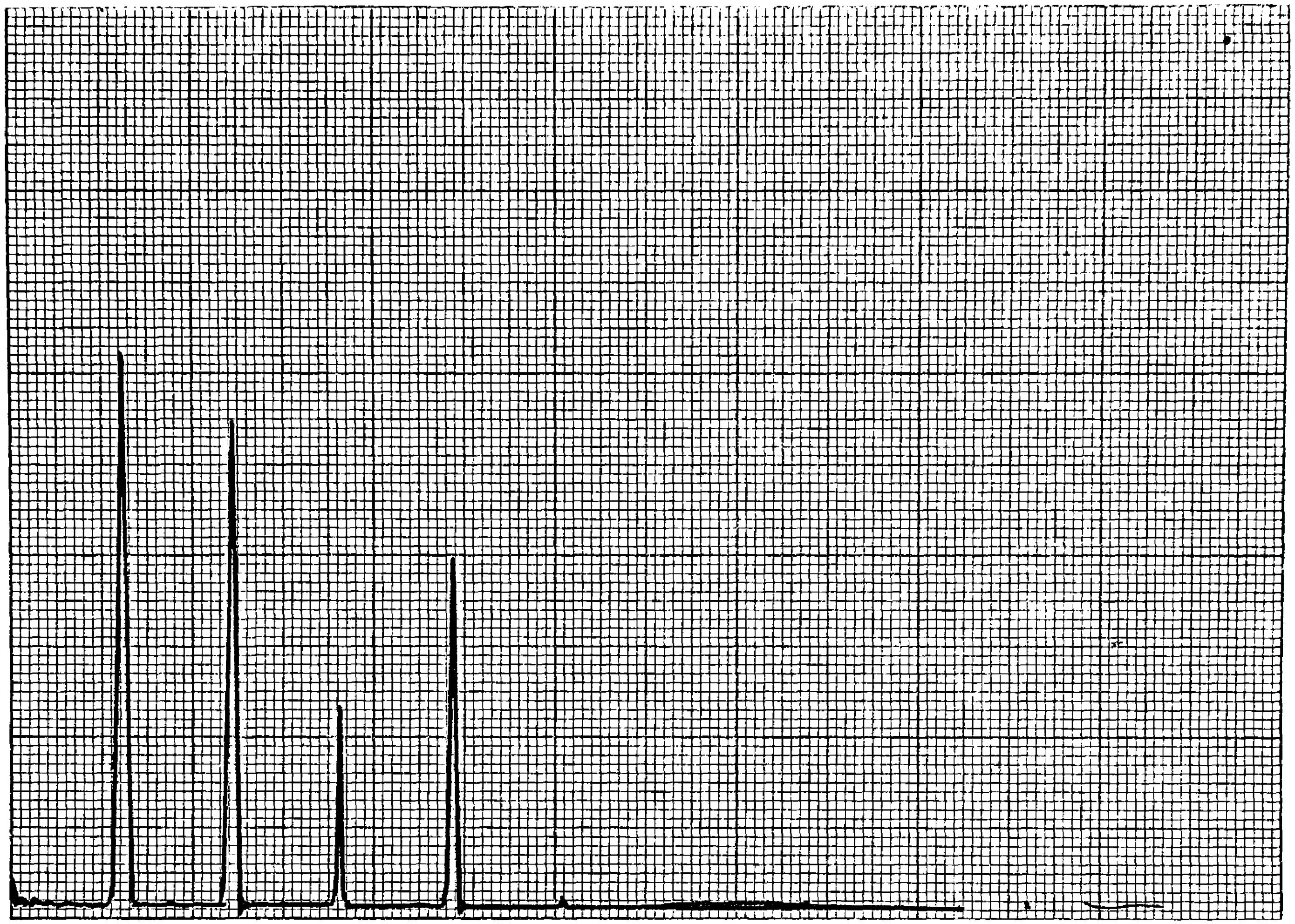
Spectrum Analysis Graph: Group III, Subject Number 21, Pitch c.



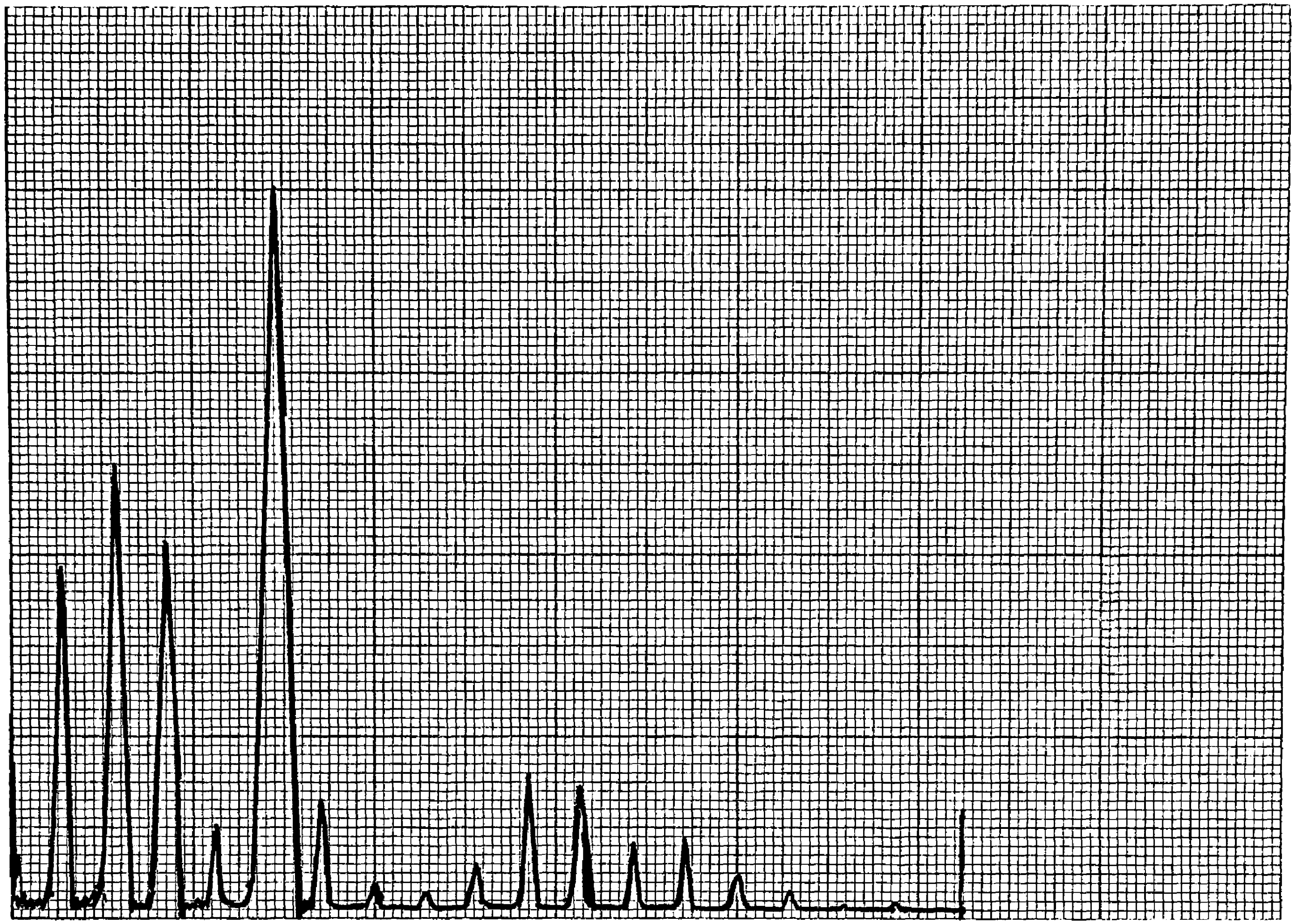
Spectrum Analysis Graph: Group III, Subject Number 21, Pitch f.



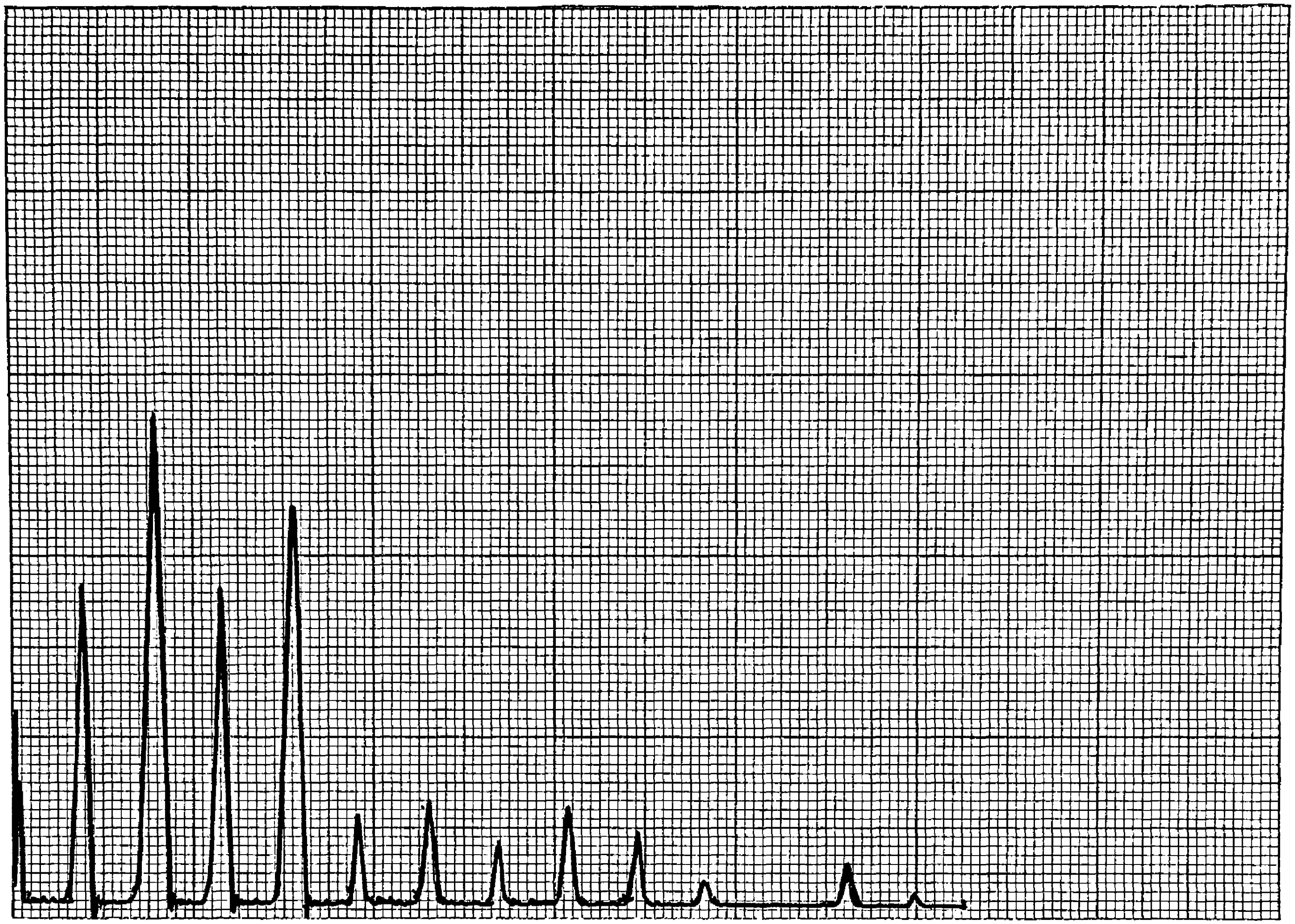
Spectrum Analysis Graph: Group III, Subject Number 21, Pitch b^b.



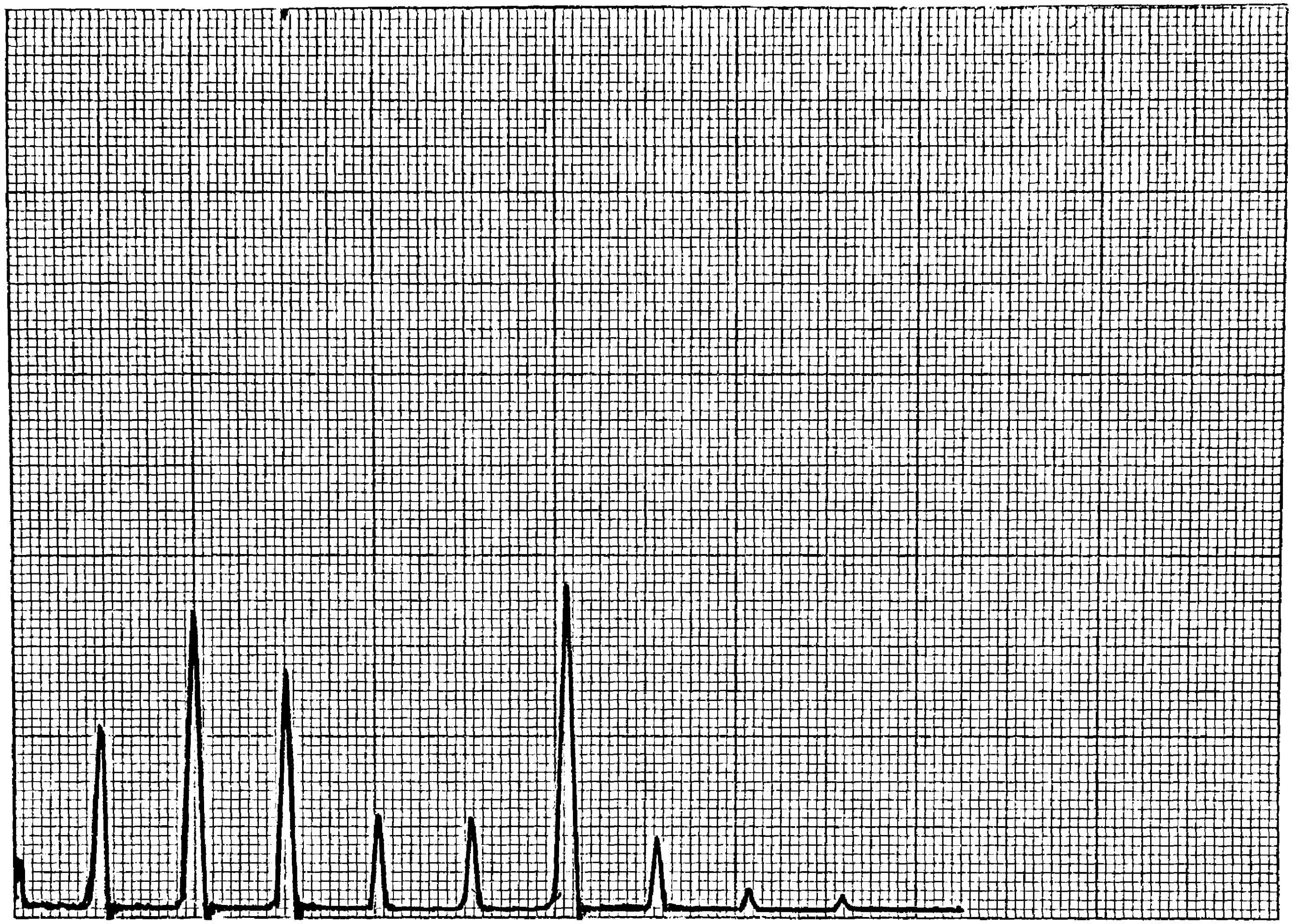
Spectrum Analysis Graph: Group III, Subject Number 21, Pitch e^b.



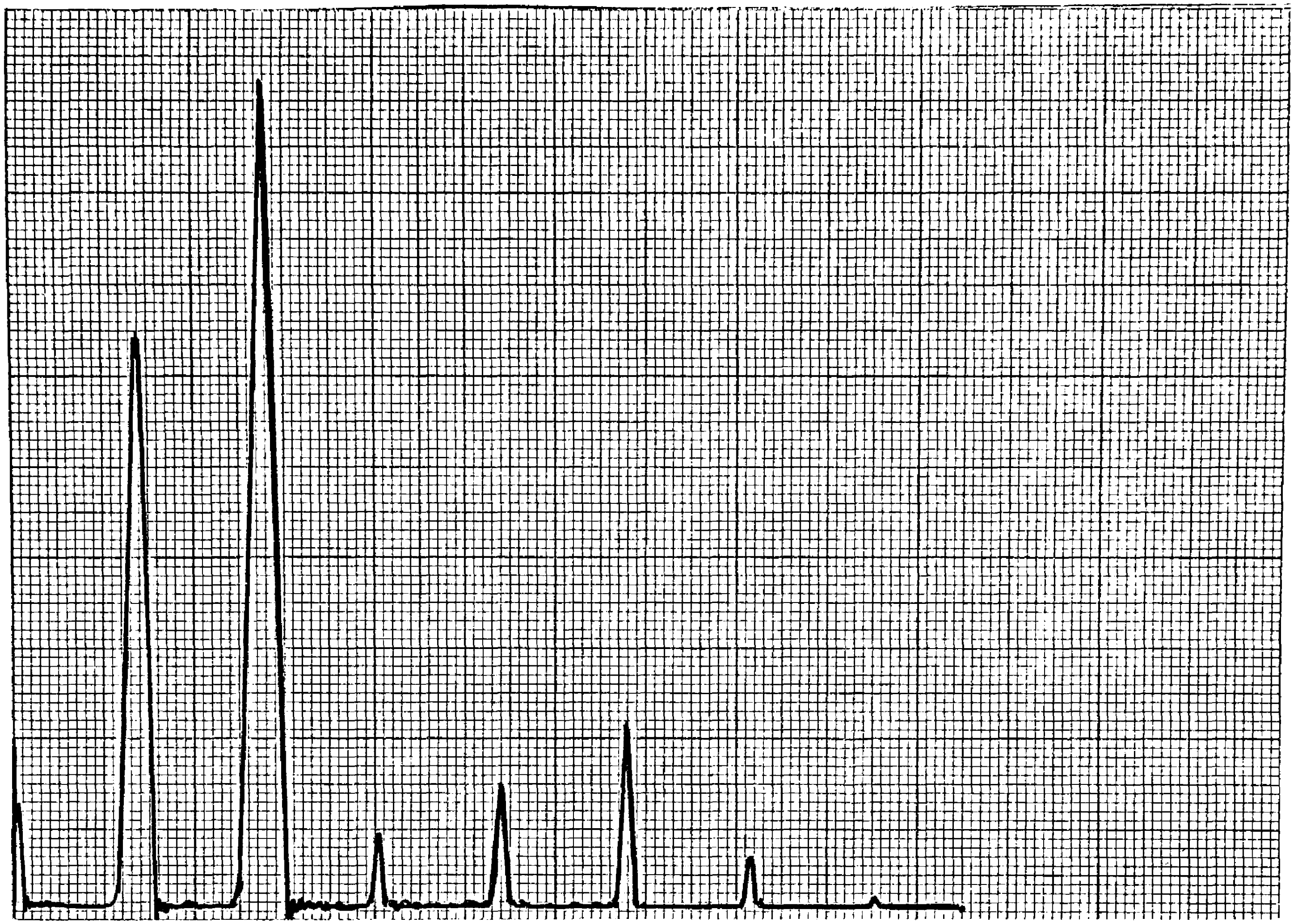
Spectrum Analysis Graph: Group III, Subject Number 31, Pitch d.



Spectrum Analysis Graph: Group III, Subject Number 31, Pitch g.



Spectrum Analysis Graph: Group III, Subject Number 31, Pitch c.



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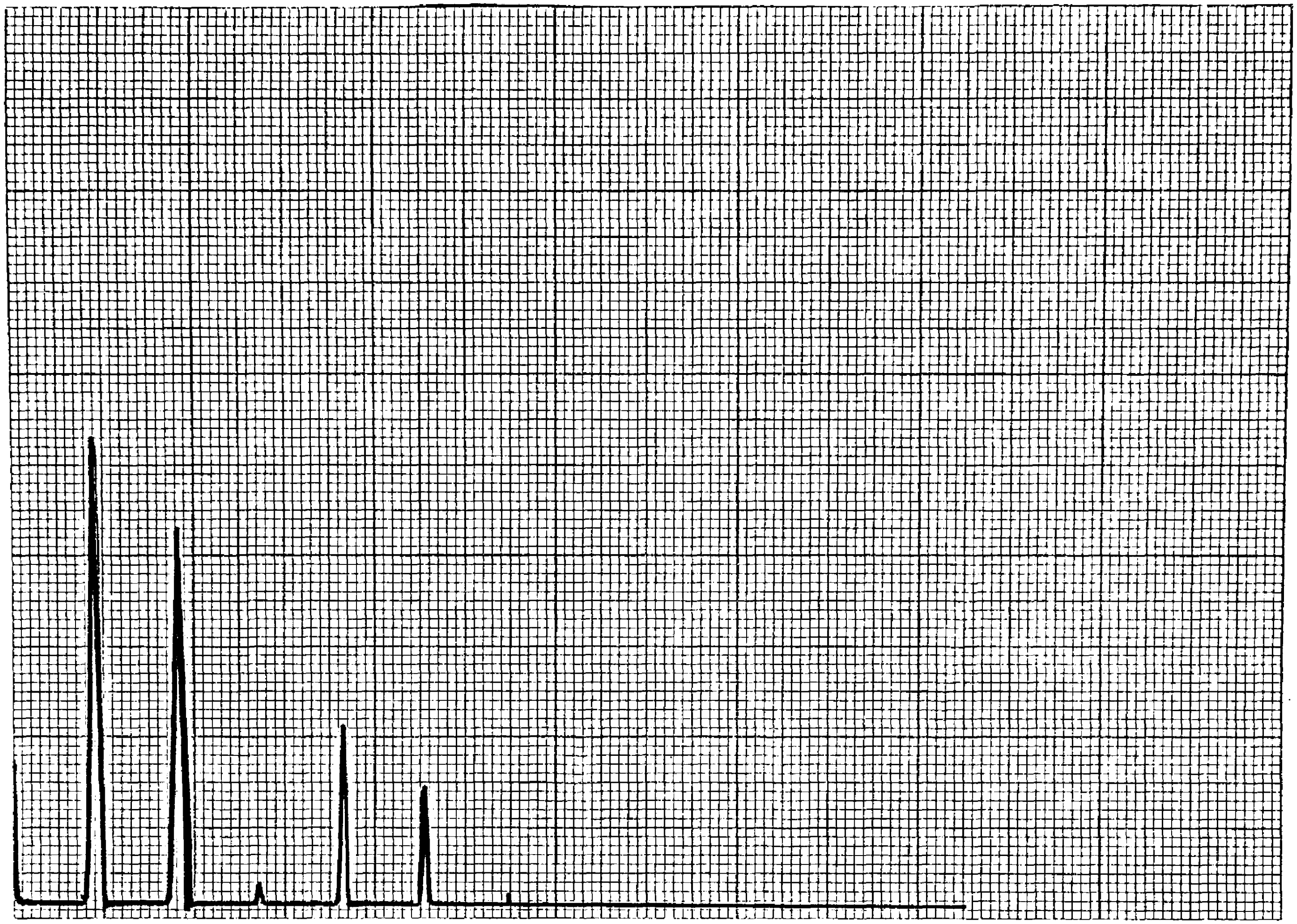
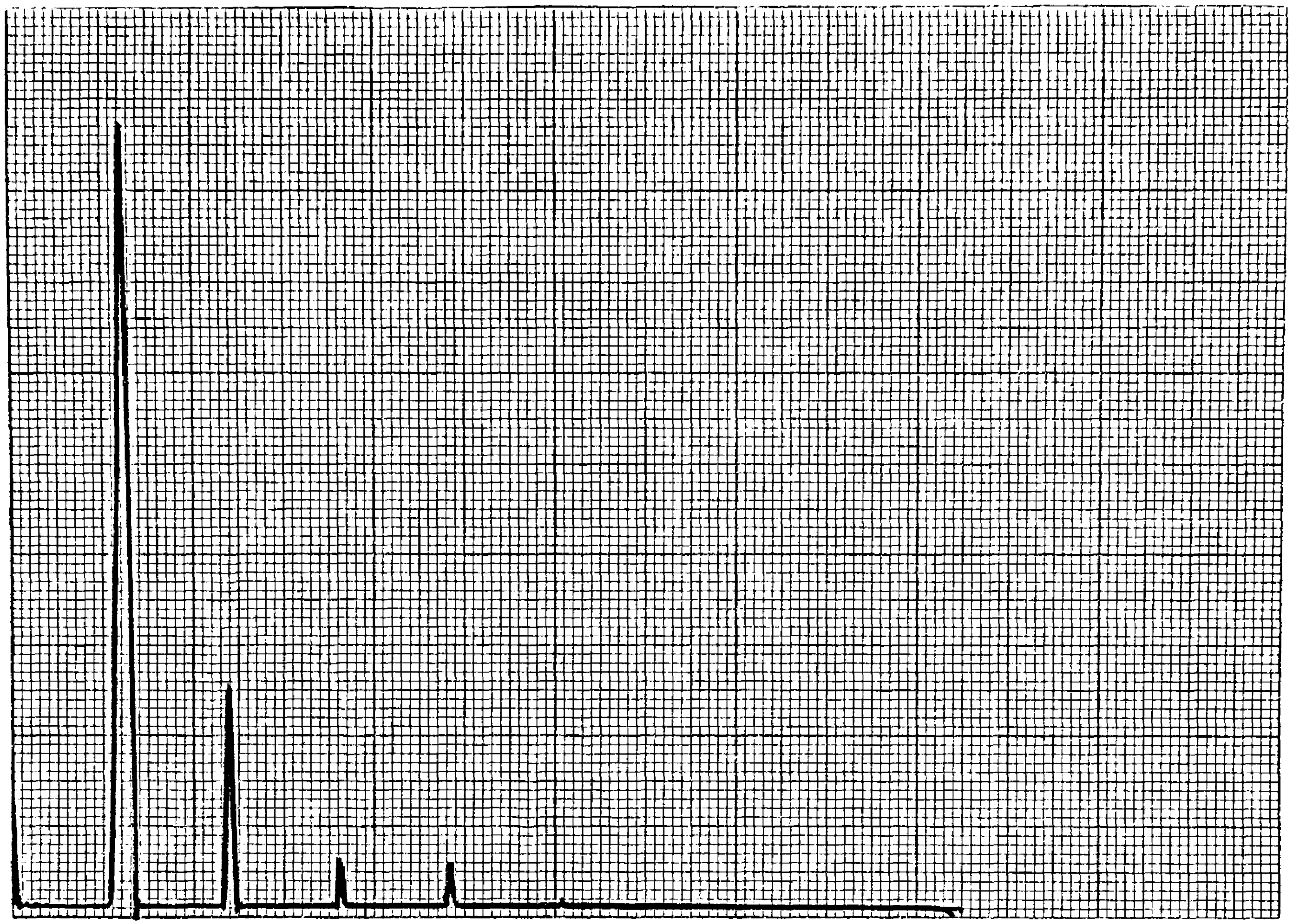
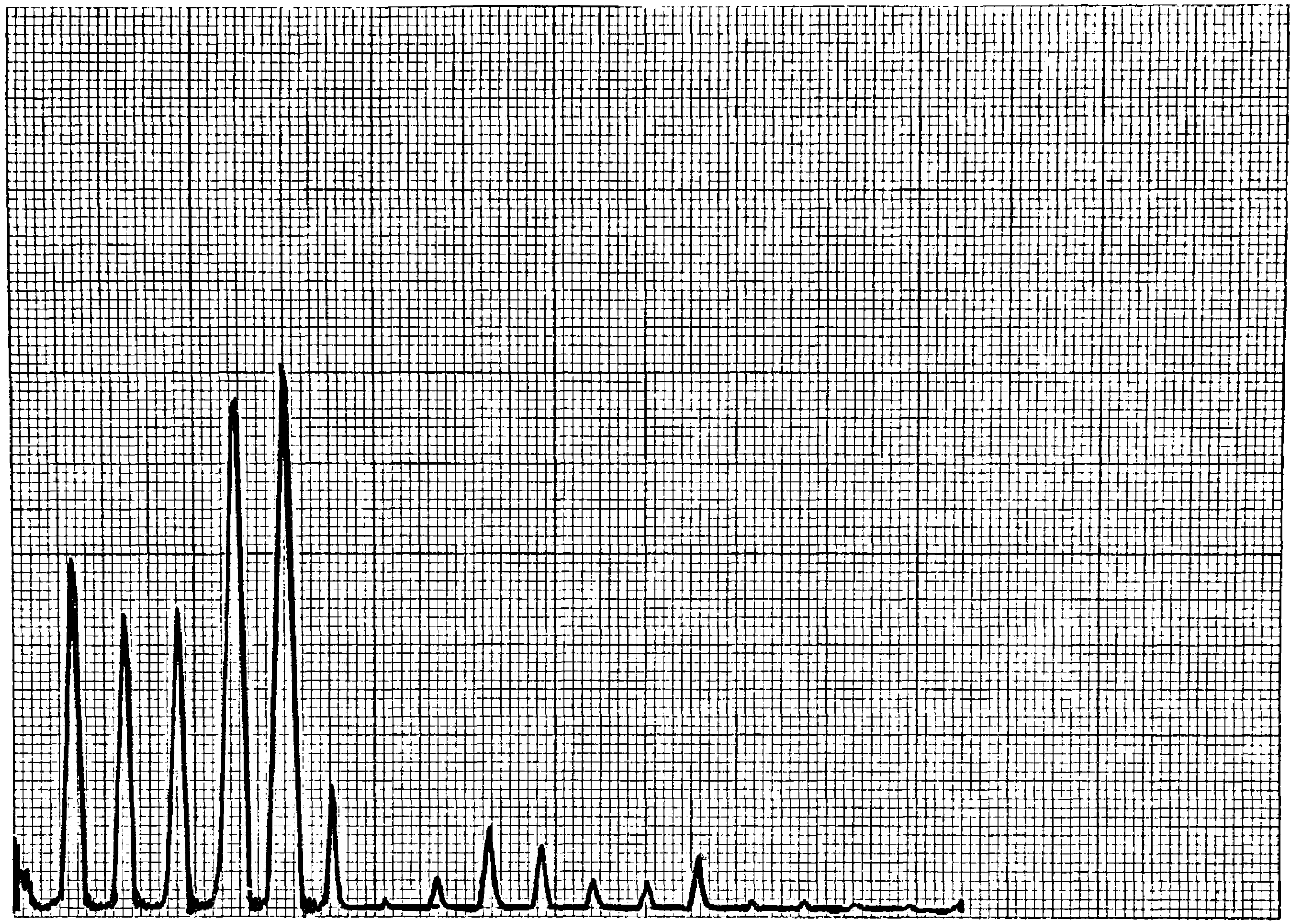


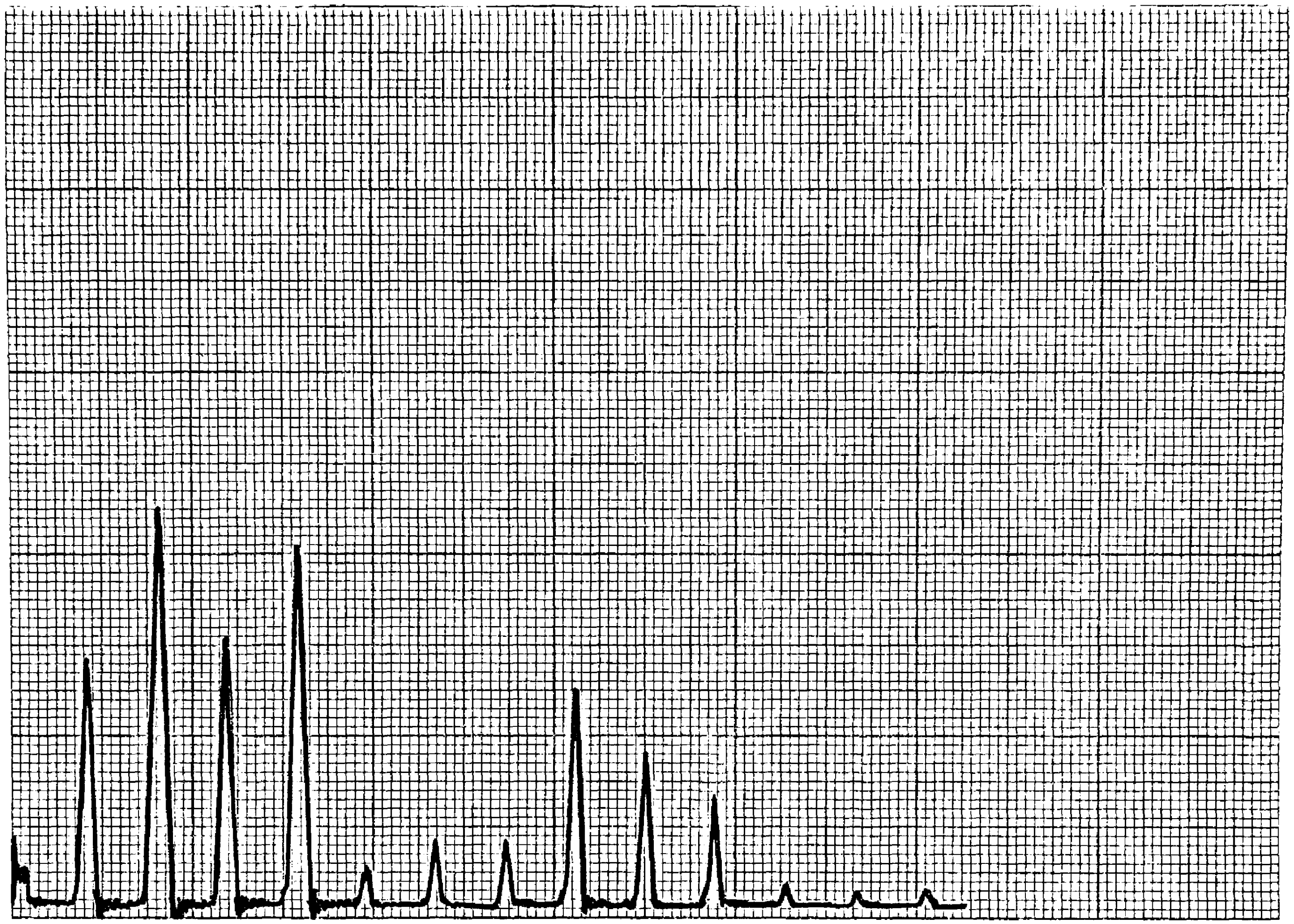
Spectrum Analysis Graph: Group III, Subject Number 31, Pitch b^{b}.



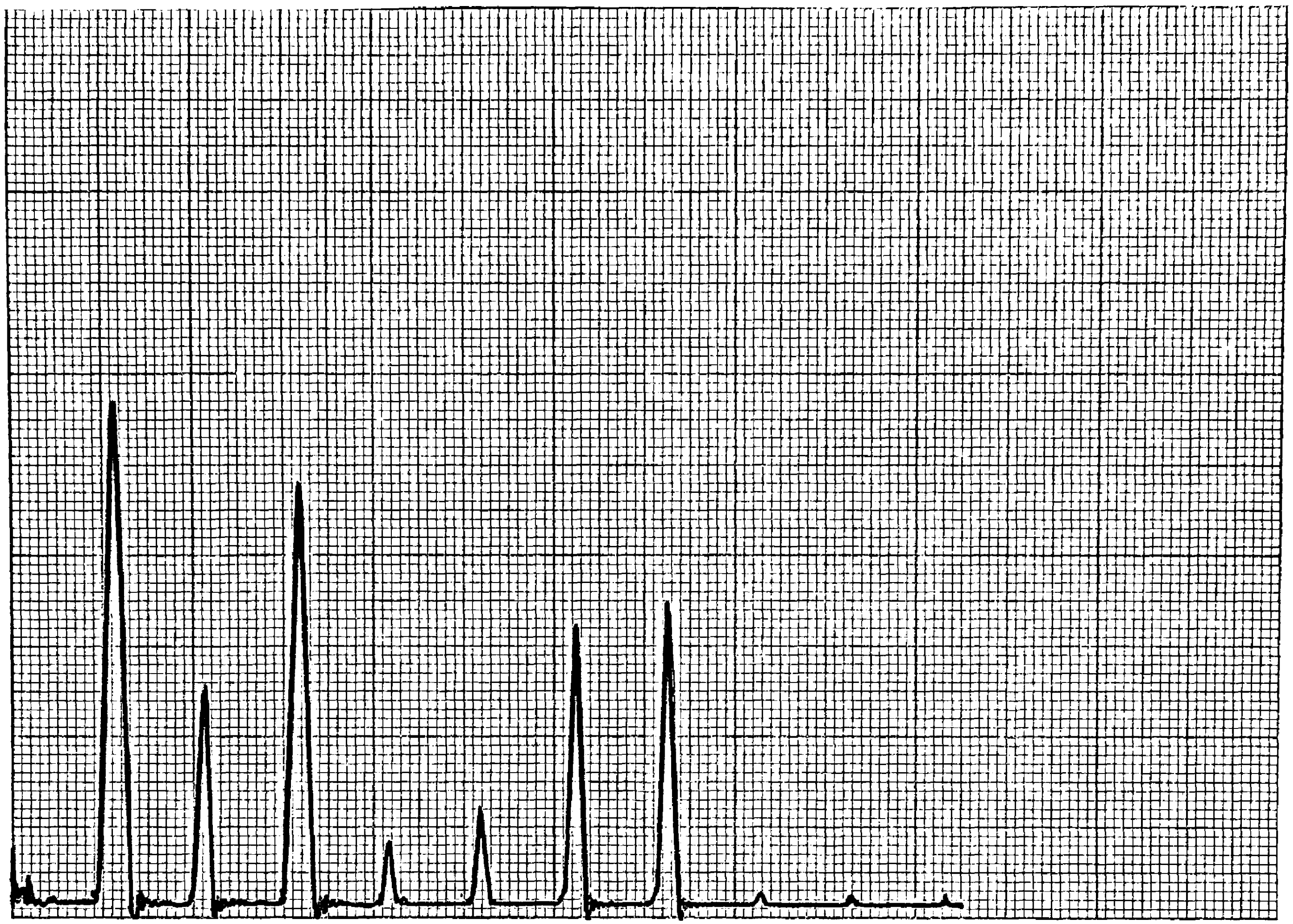
Spectrum Analysis Graph: Group III, Subject Number 31, Pitch e^b.



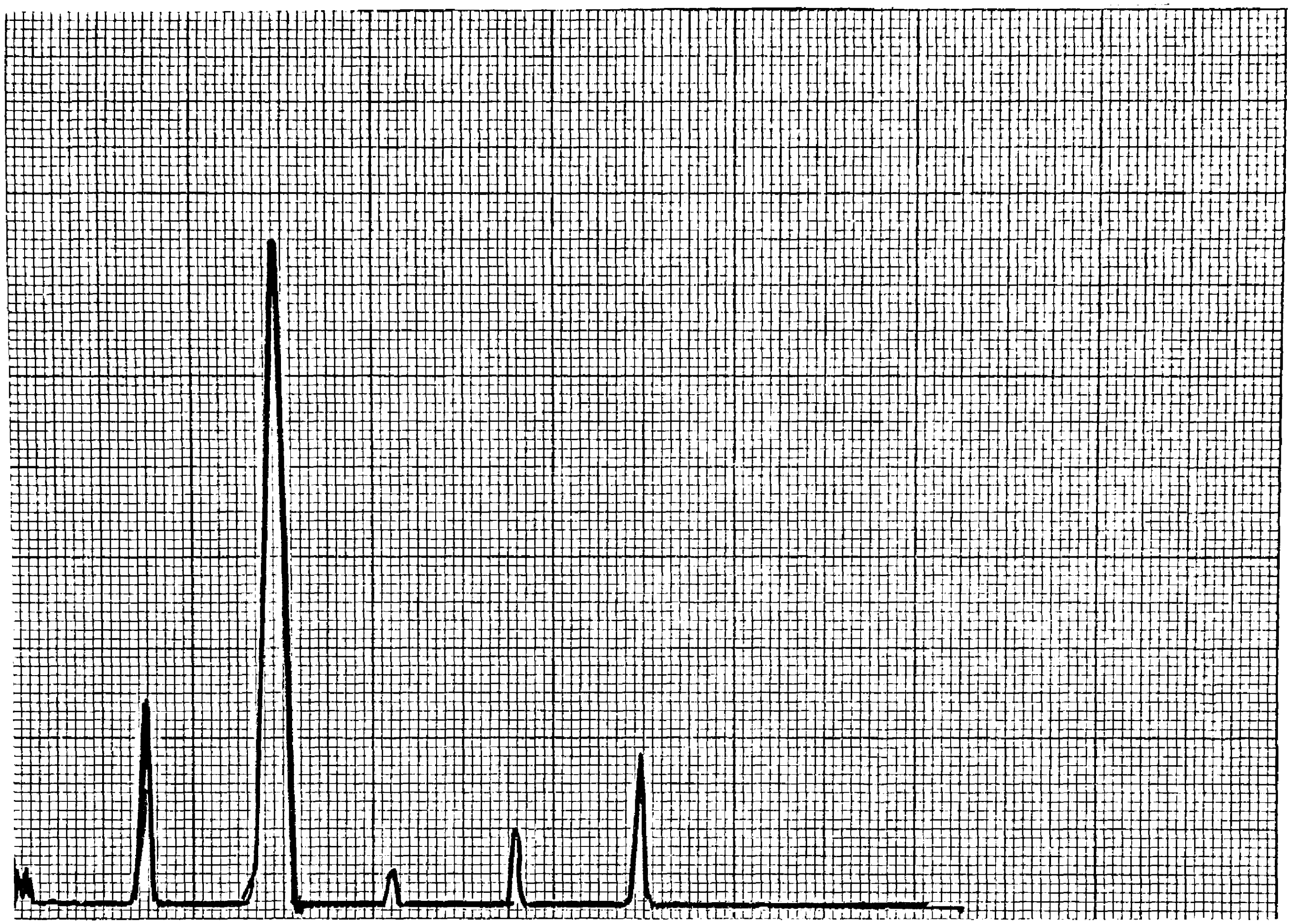
Spectrum Analysis Graph: Group III, Subject Number 32, Pitch d.



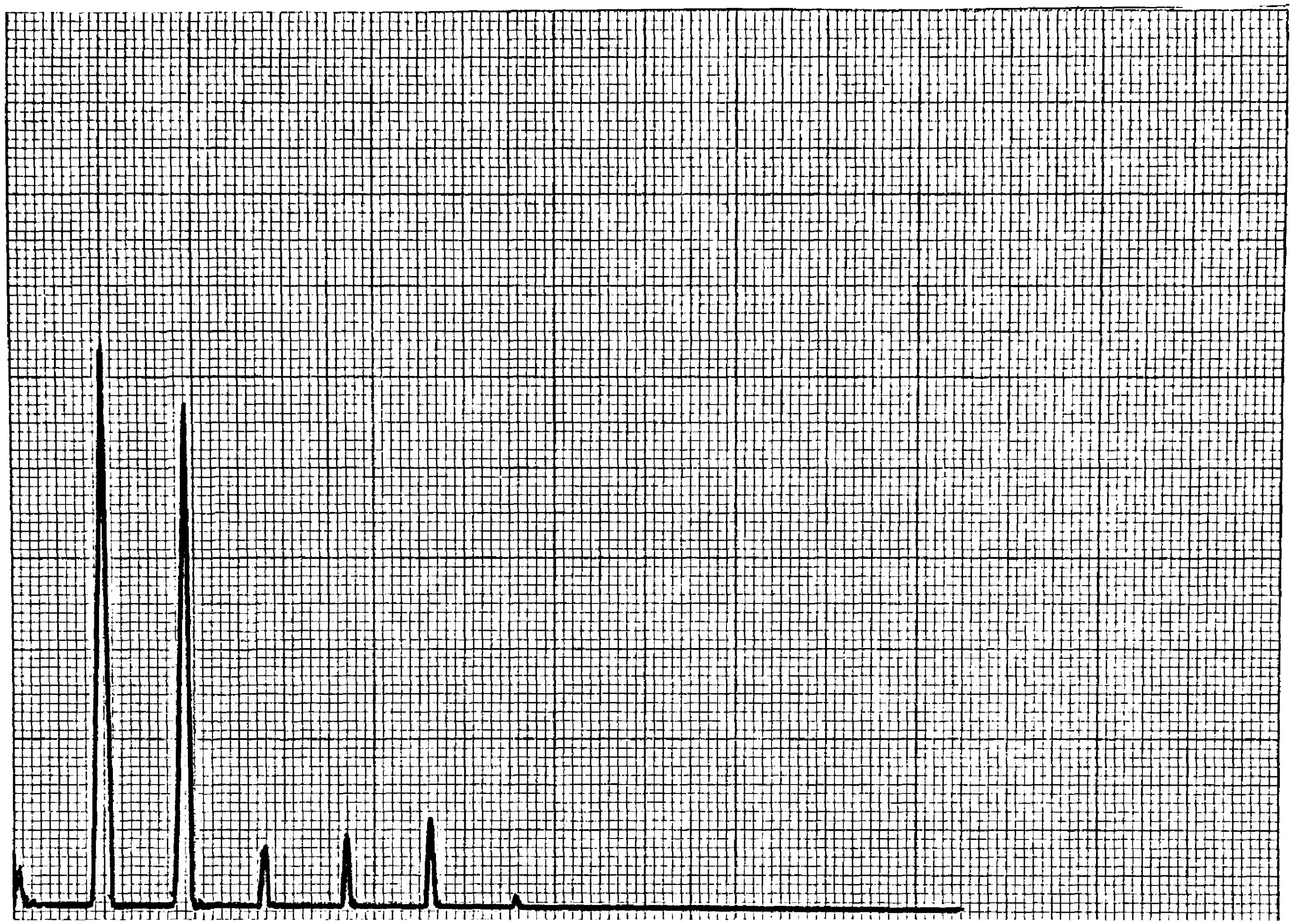
Spectrum Analysis Graph: Group III, Subject Number 32, Pitch g.



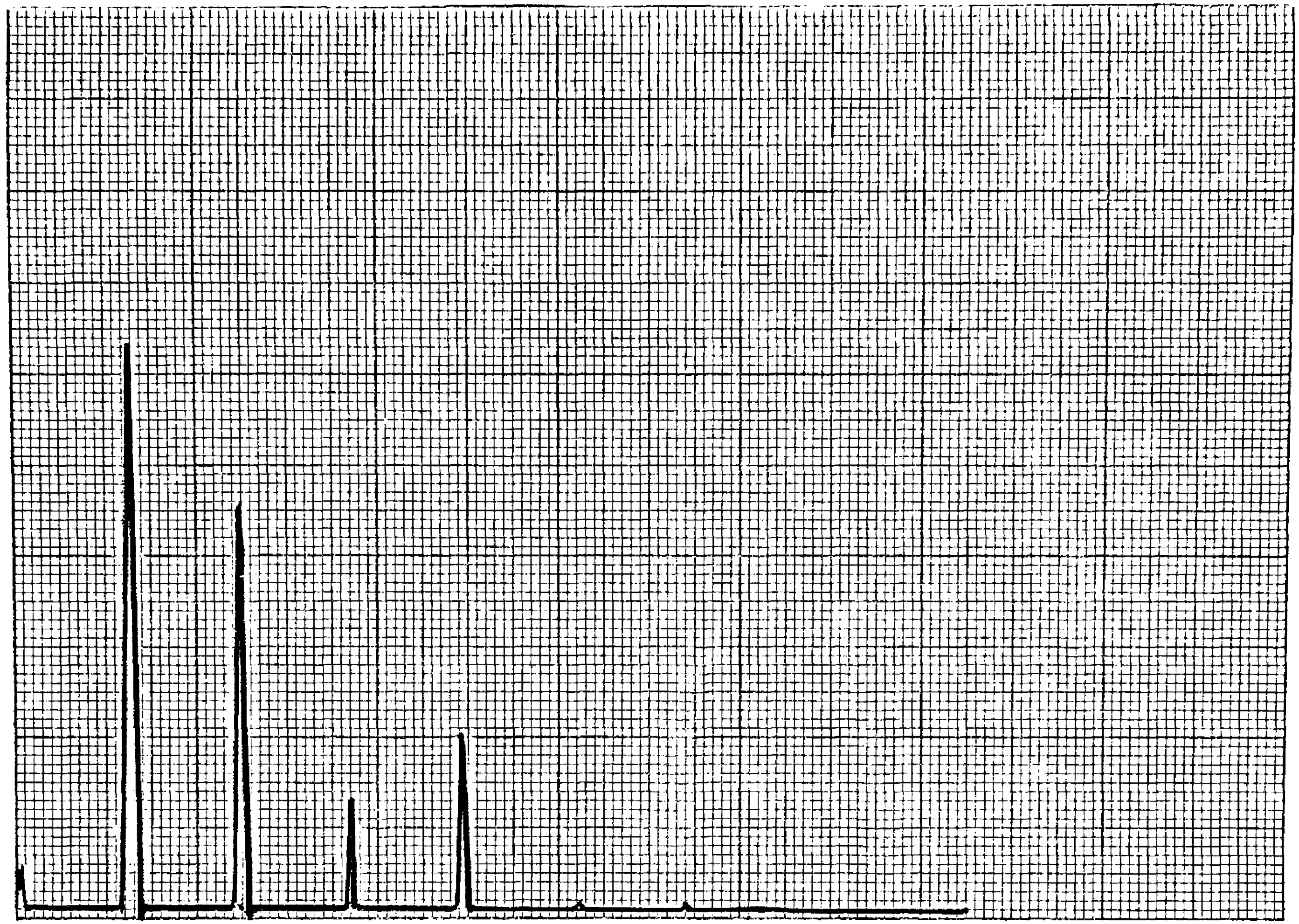
Spectrum Analysis Graph: Group III, Subject Number 32, Pitch c.



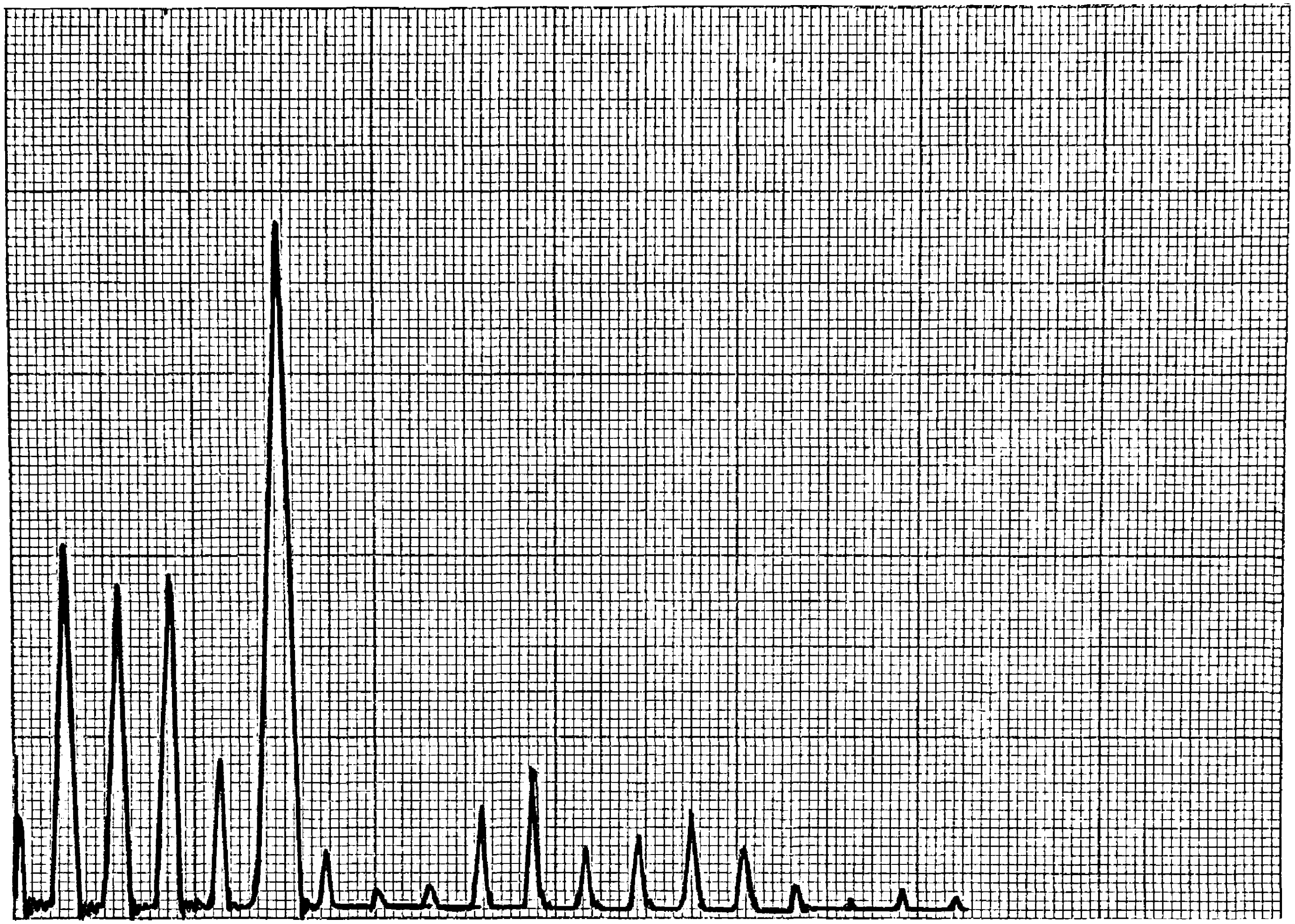
Spectrum Analysis Graph: Group III, Subject Number 32, Pitch f.



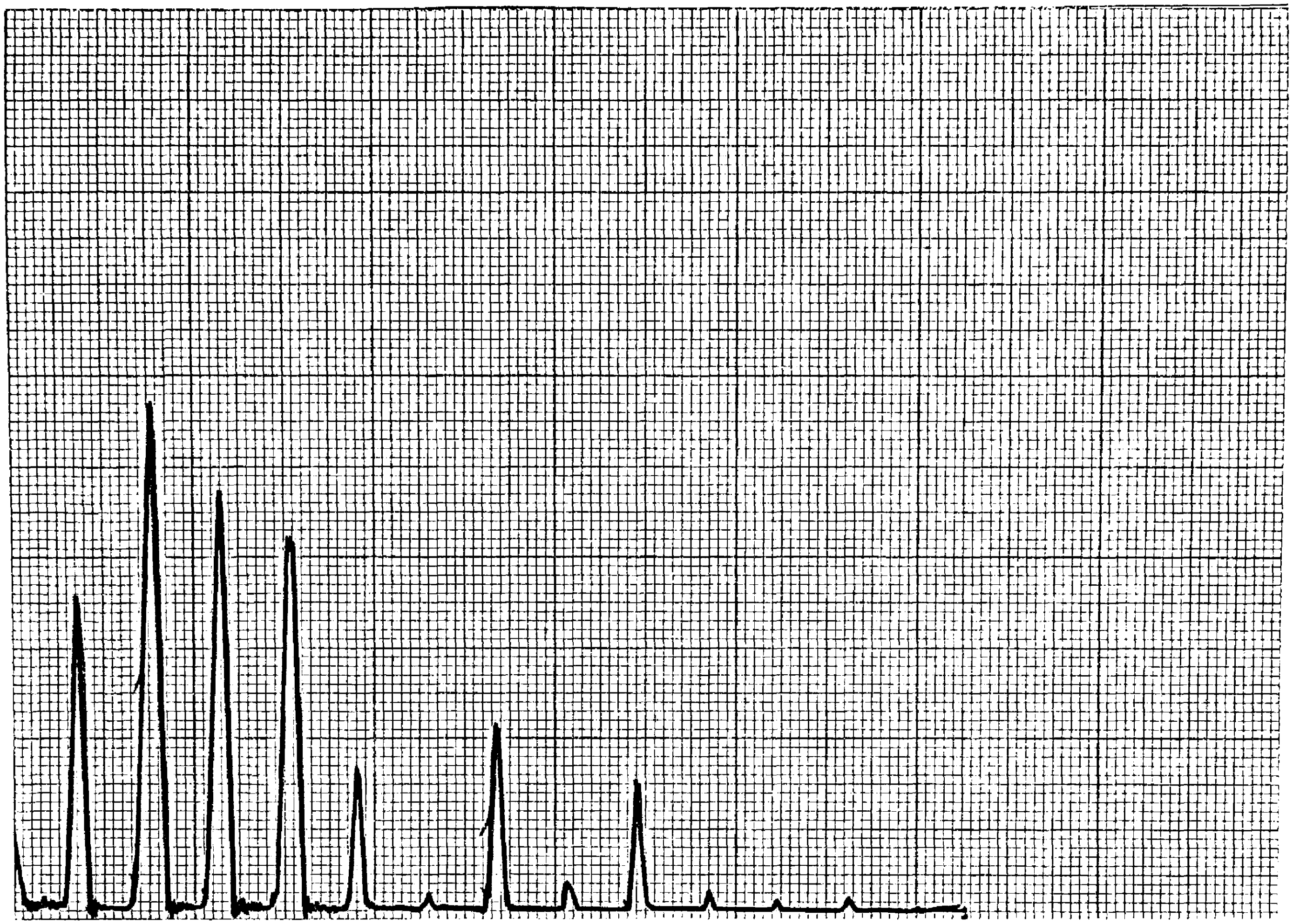
Spectrum Analysis Graph: Group III, Subject Number 32, Pitch b^b.



Spectrum Analysis Graph: Group III, Subject Number 32, Pitch e^b.

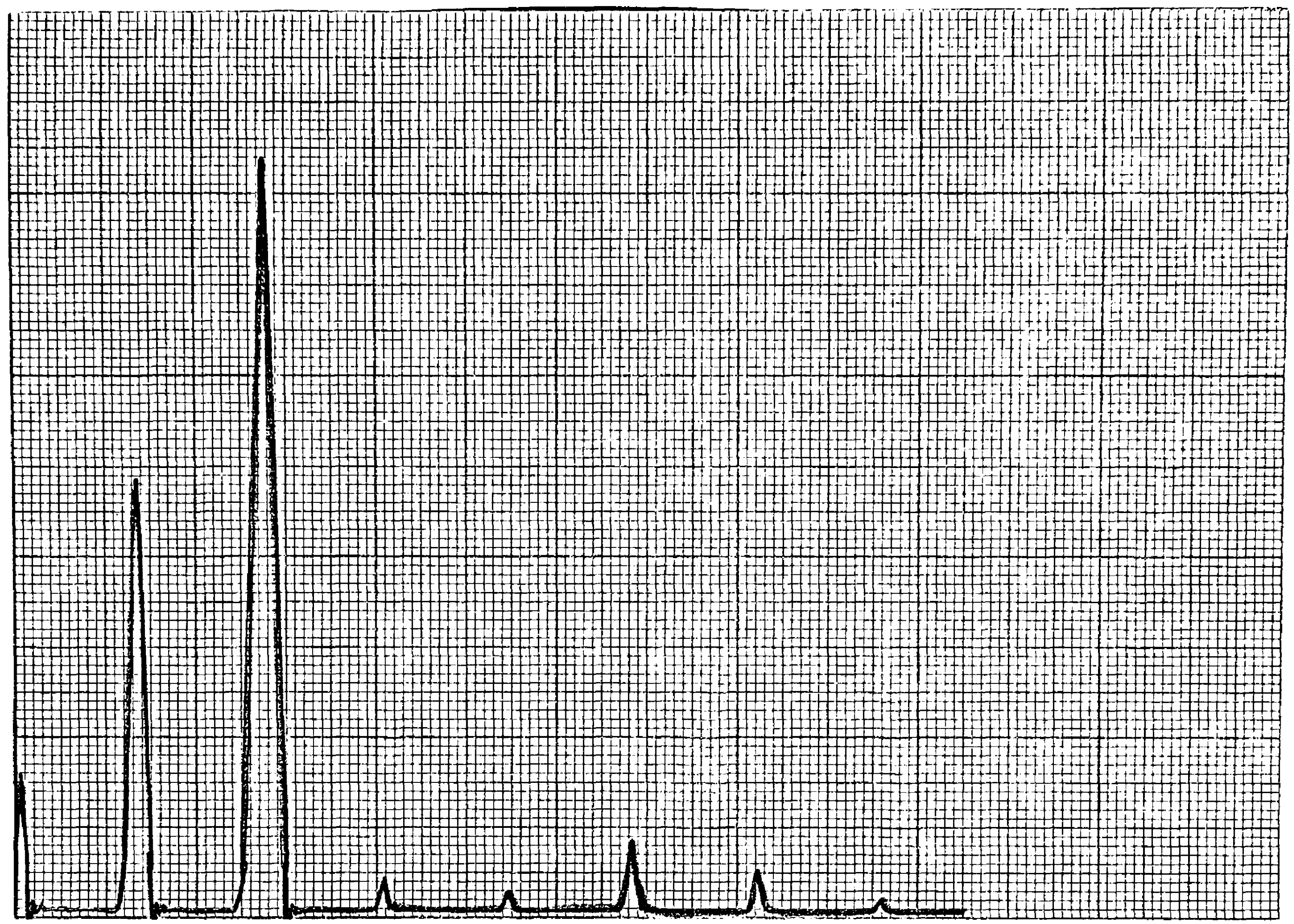


Spectrum Analysis Graph: Group III, Subject Number 33, Pitch d.

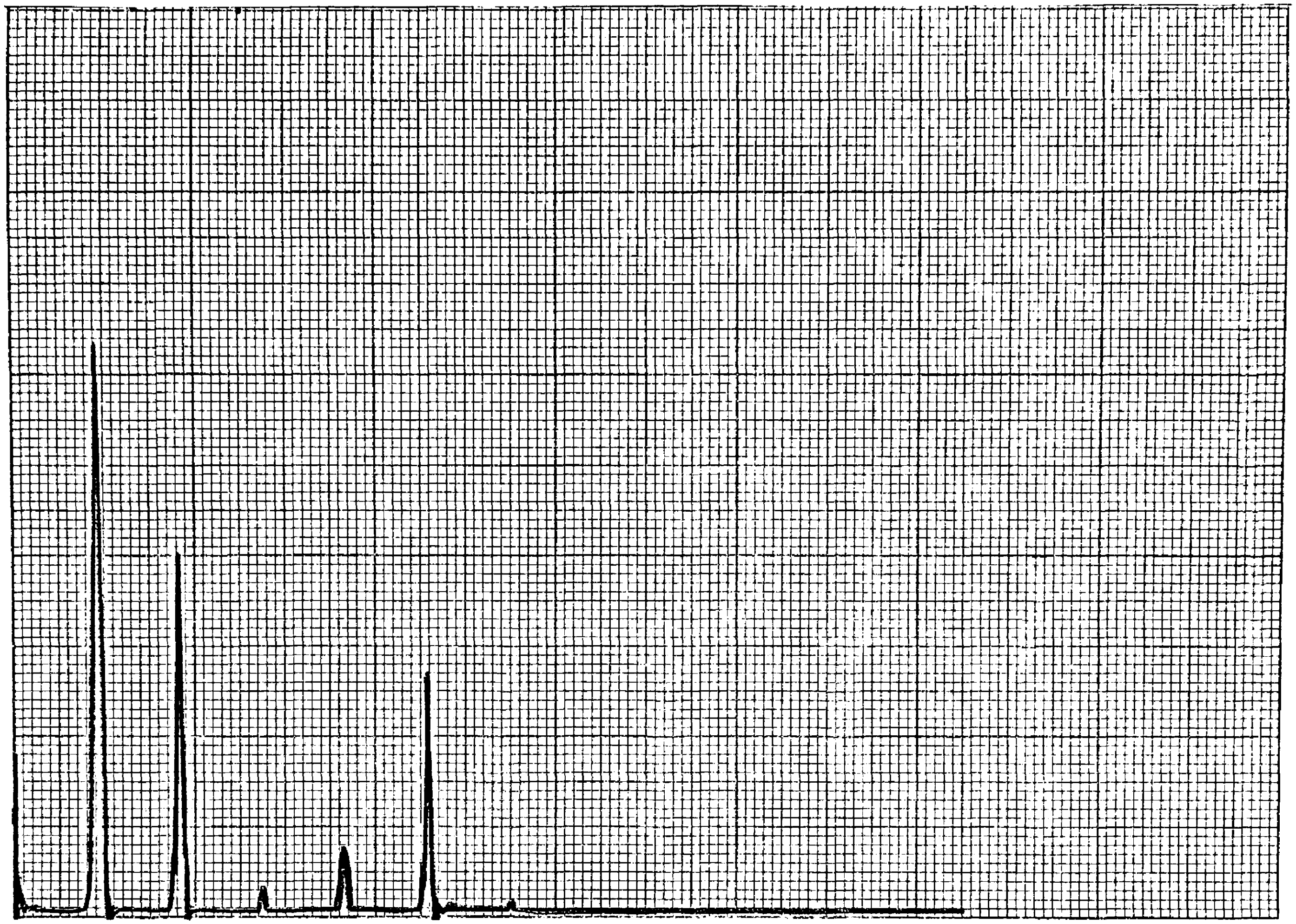


Spectrum Analysis Graph: Group III, Subject Number 33, Pitch g.

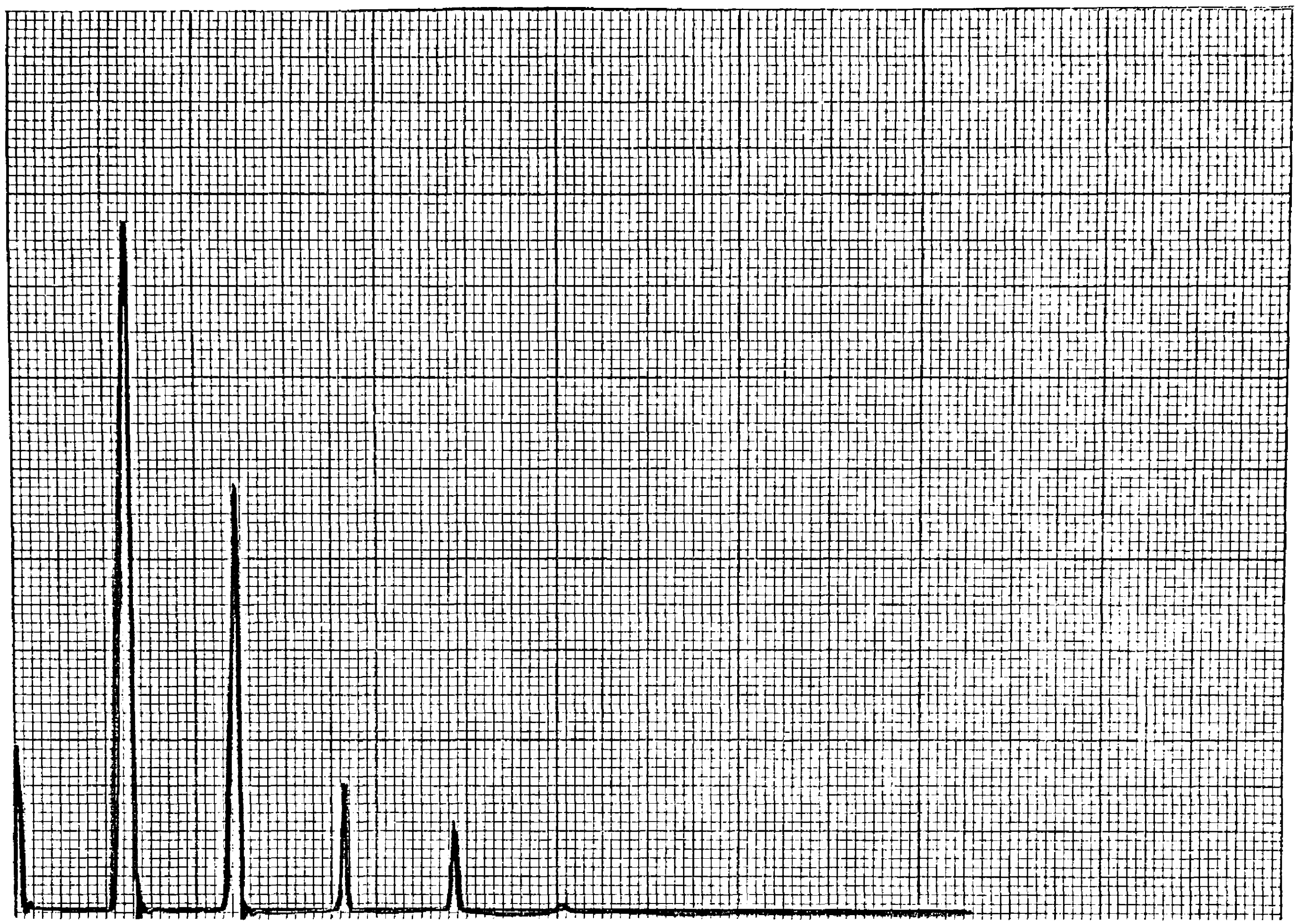
Spectrum Analysis Graph: Group III, Subject Number 33, Pitch c.



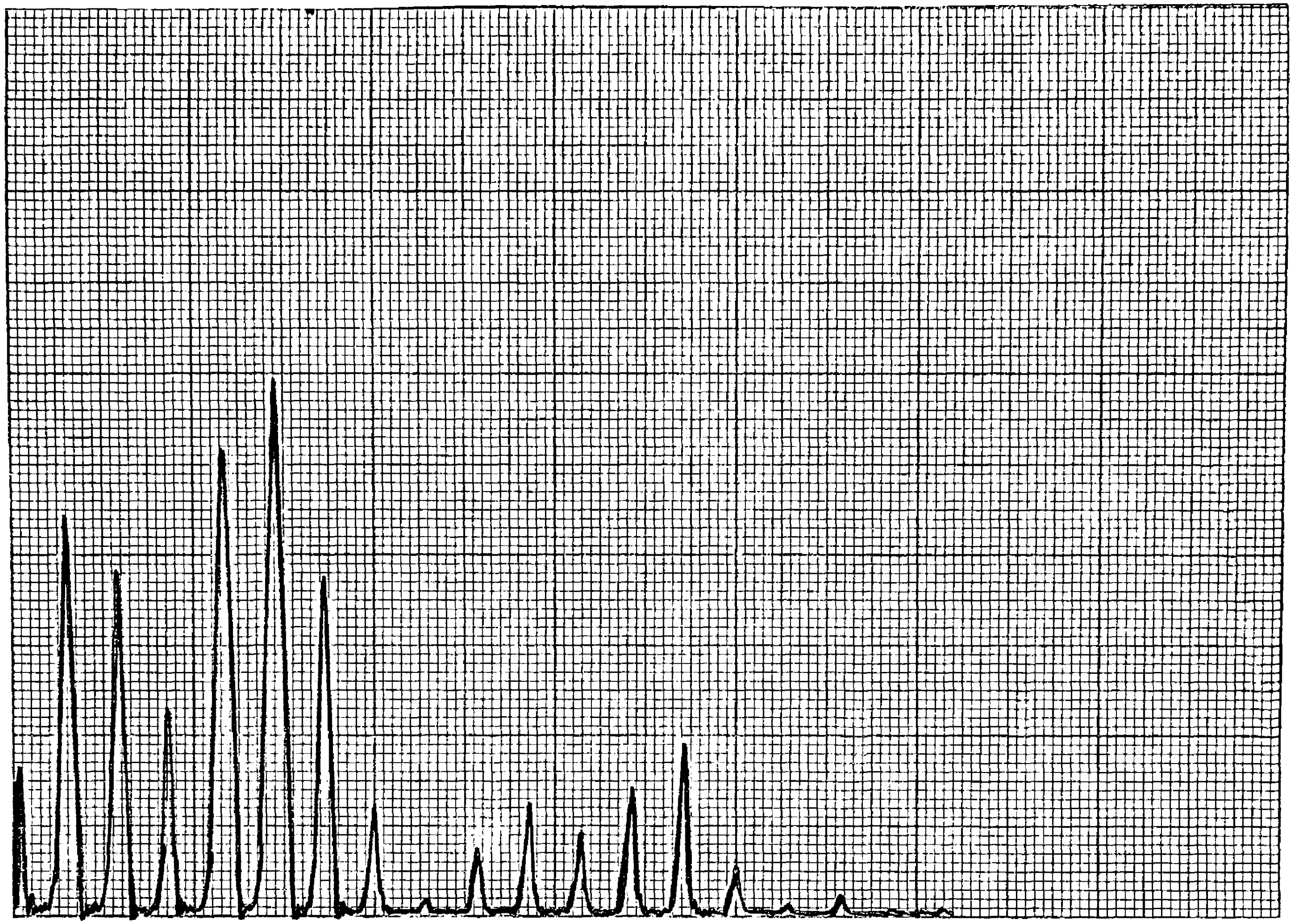
Spectrum Analysis Graph: Group III, Subject Number 33, Pitch f.



Spectrum Analysis Graph: Group III, Subject Number 33, Pitch b^{b}.

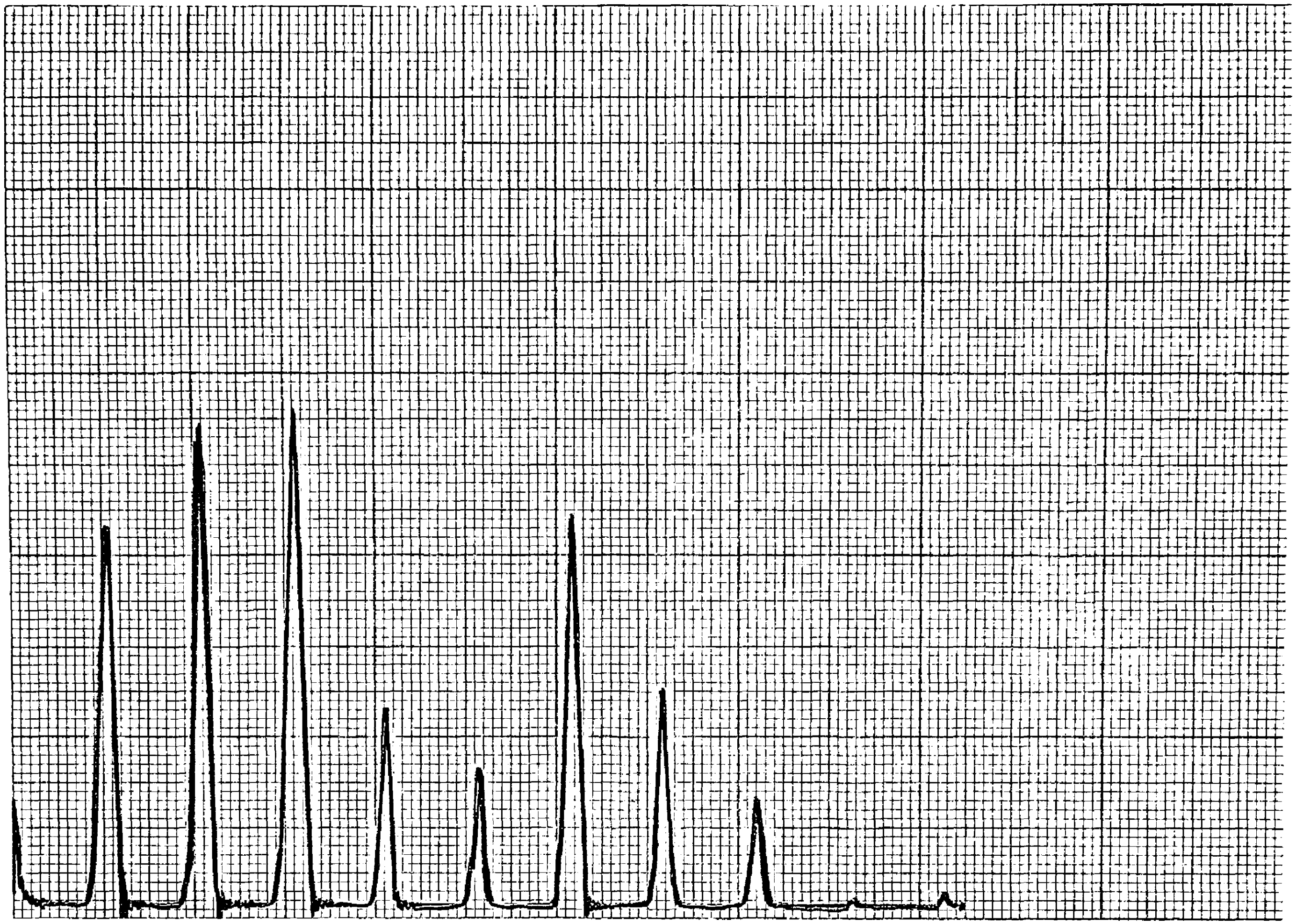


Spectrum Analysis Graph: Group III, Subject Number 33, Pitch e^b.

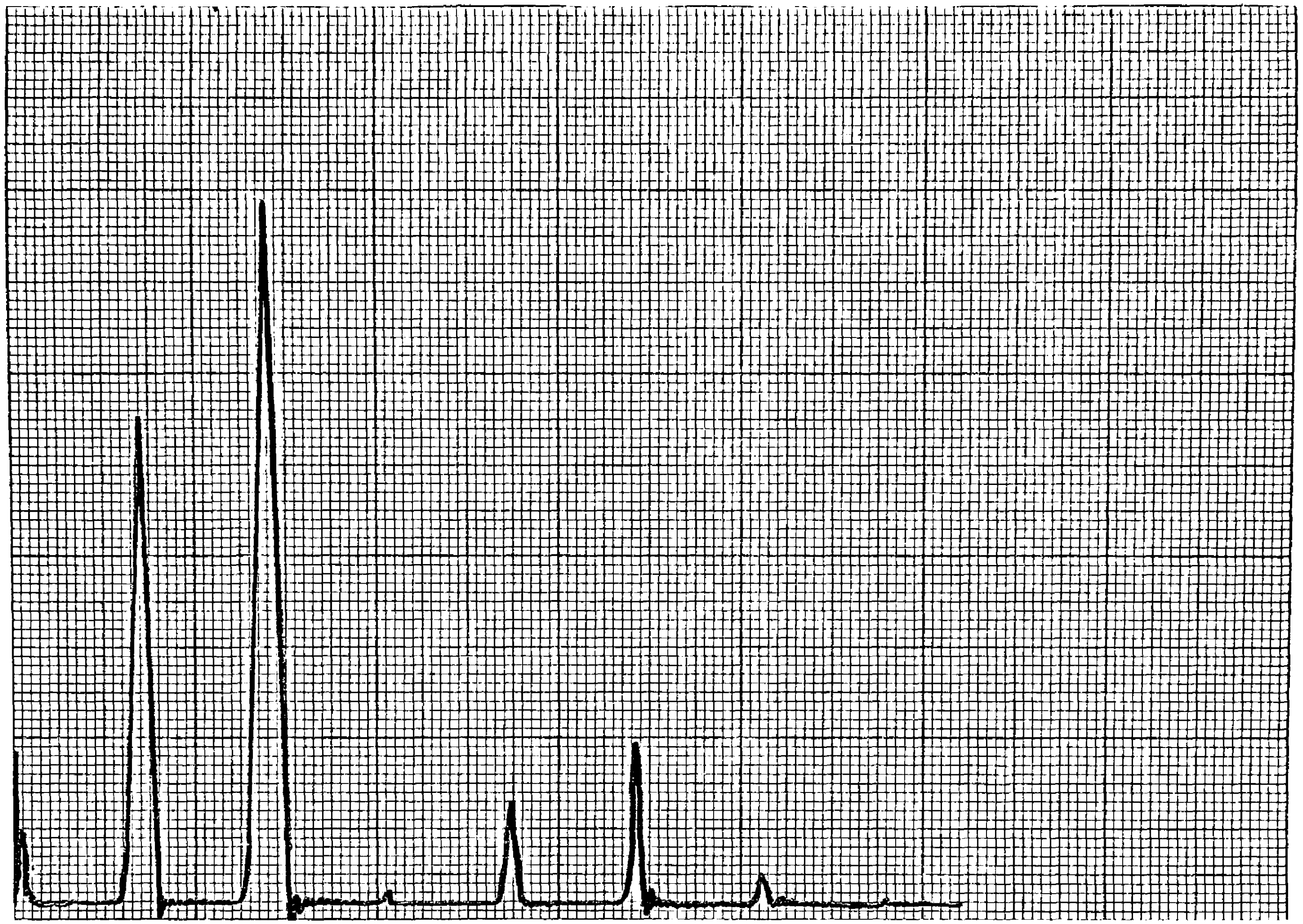


Spectrum Analysis Graph: Group III, Subject Number 43, Pitch d.

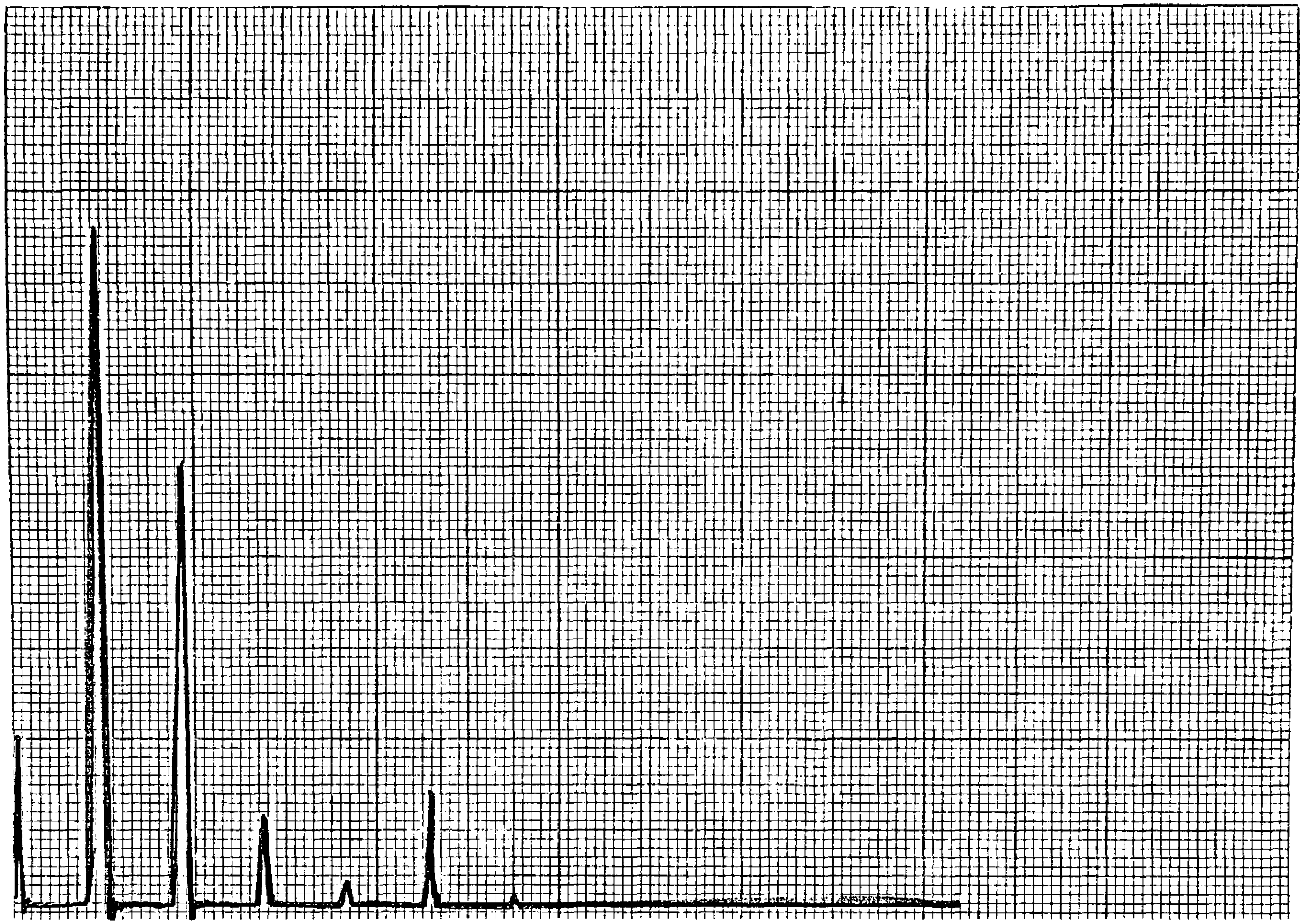
Spectrum Analysis Graph: Group III, Subject Number 43, Pitch g.



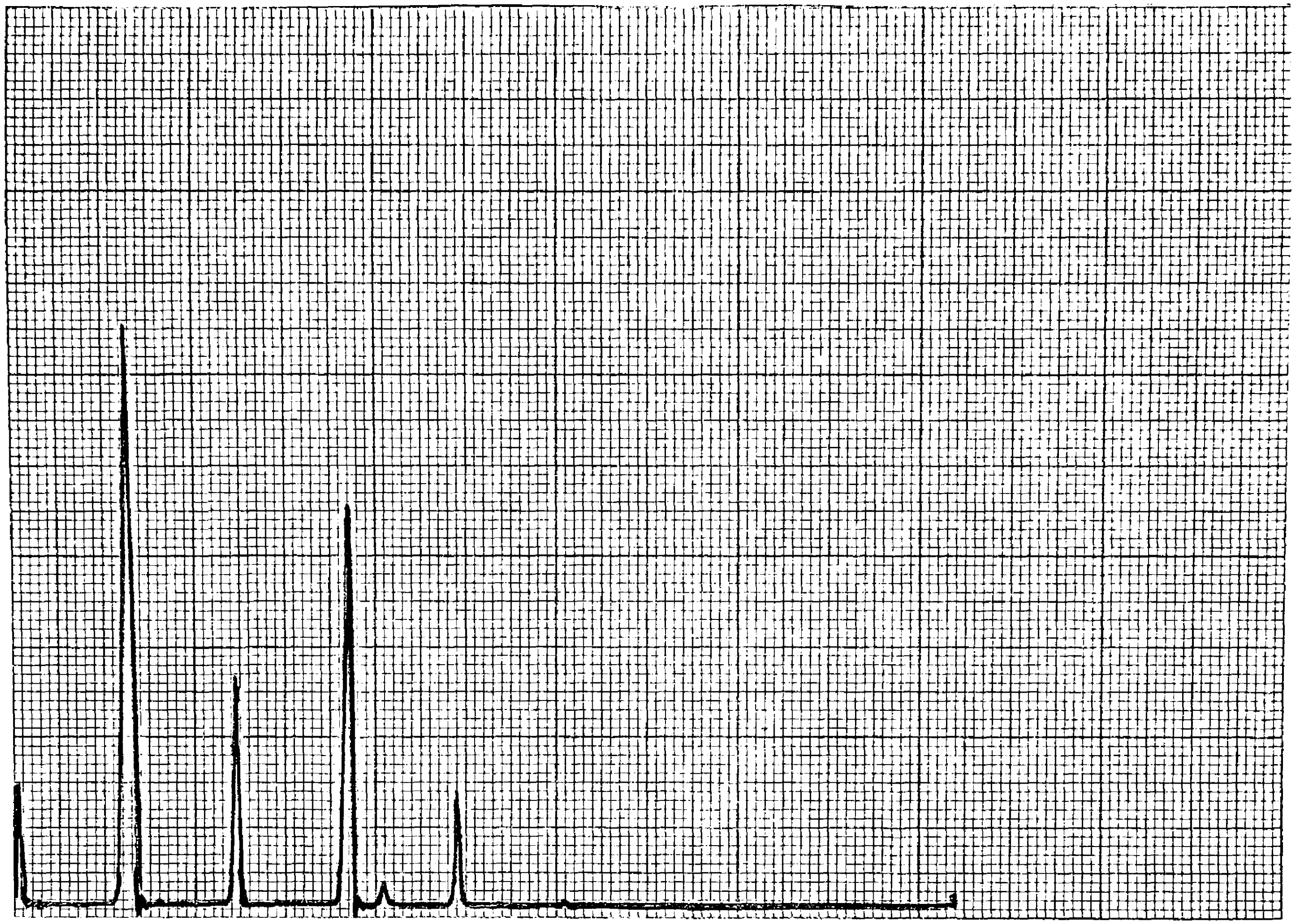
Spectrum Analysis Graph: Group III, Subject Number 43, Pitch c.



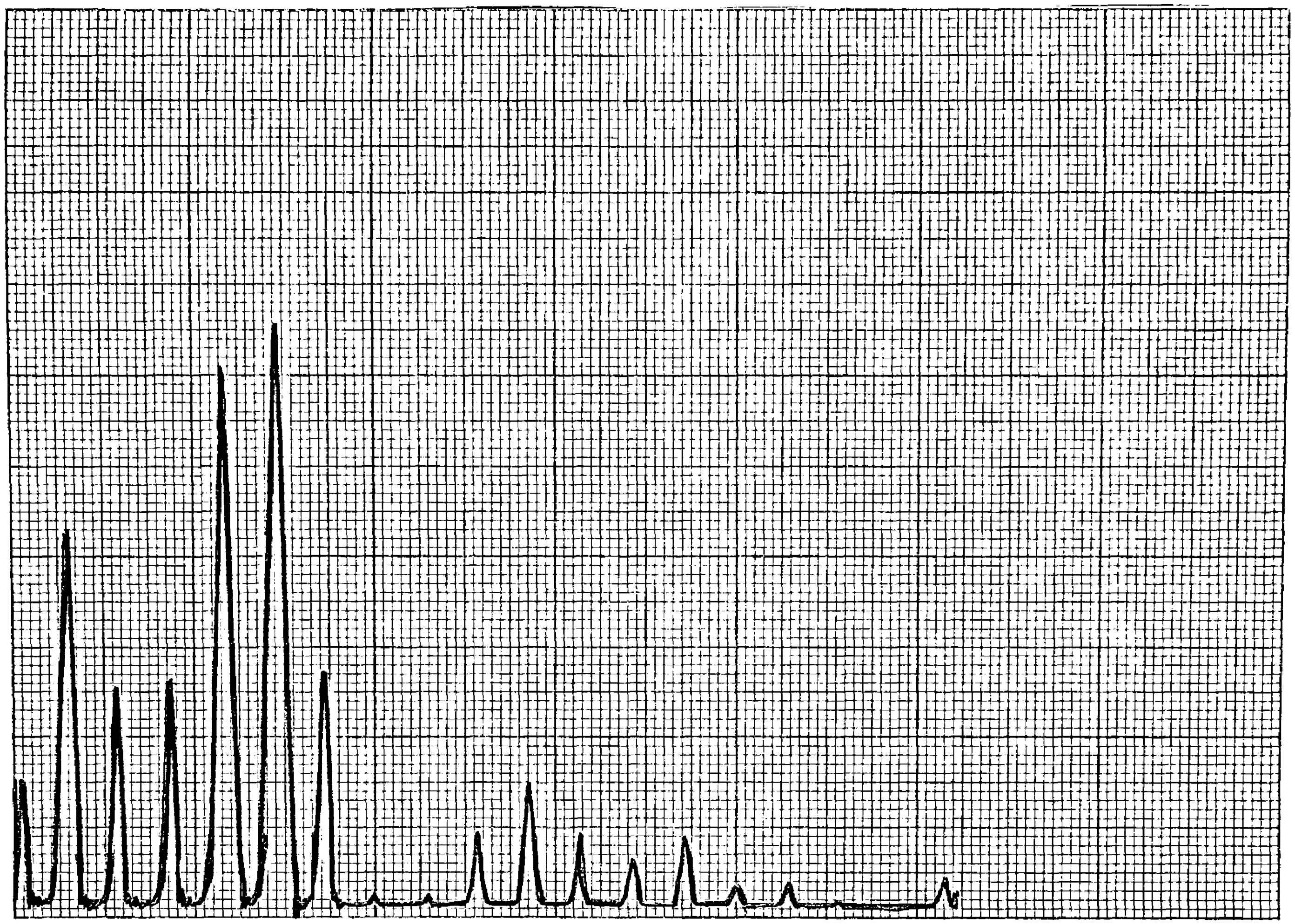
Spectrum Analysis Graph: Group III, Subject Number 43, Pitch f.



Spectrum Analysis Graph: Group III, Subject Number 43, Pitch b^{b}.



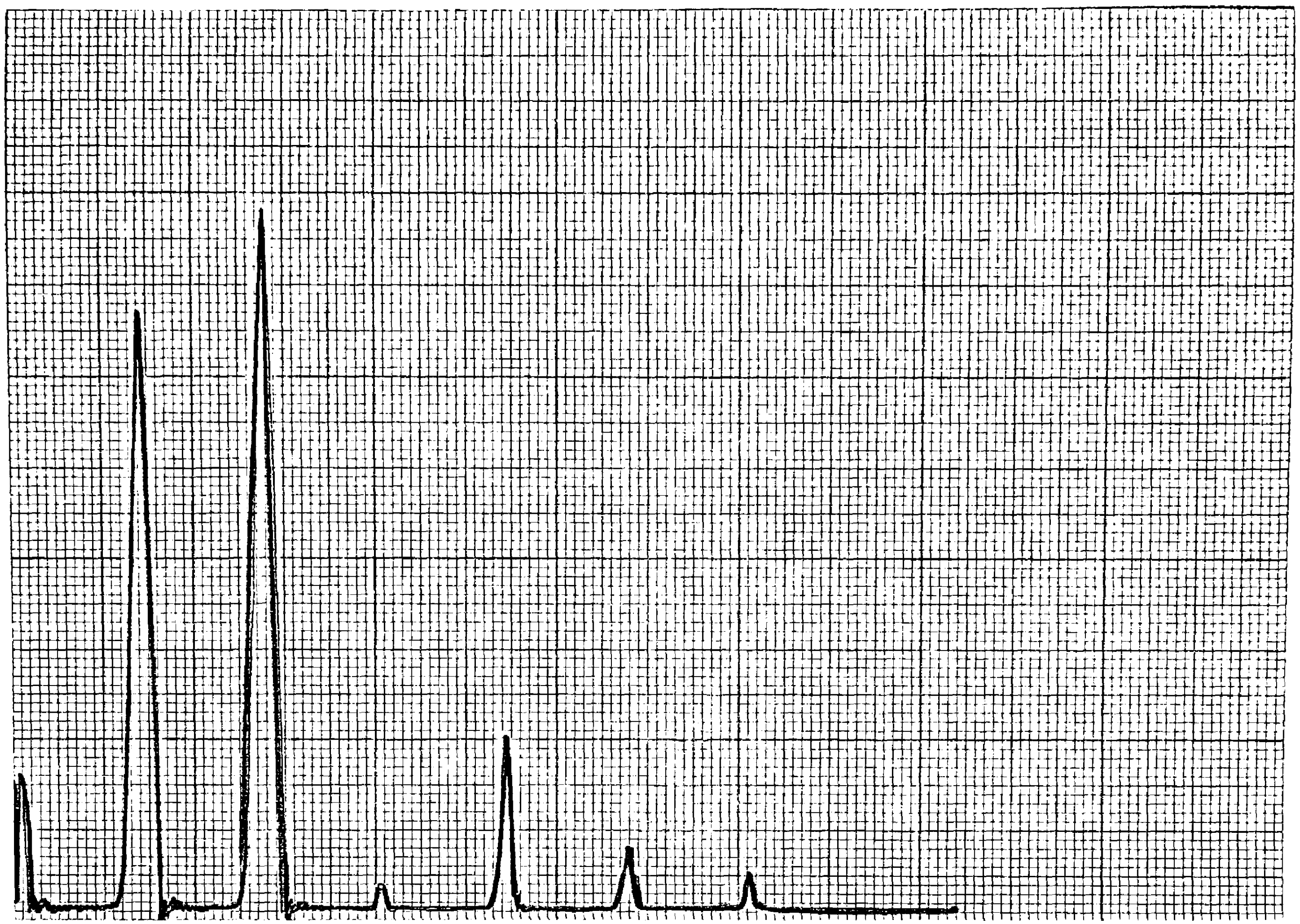
Spectrum Analysis Graph: Group III, Subject Number 43, Pitch e^b.



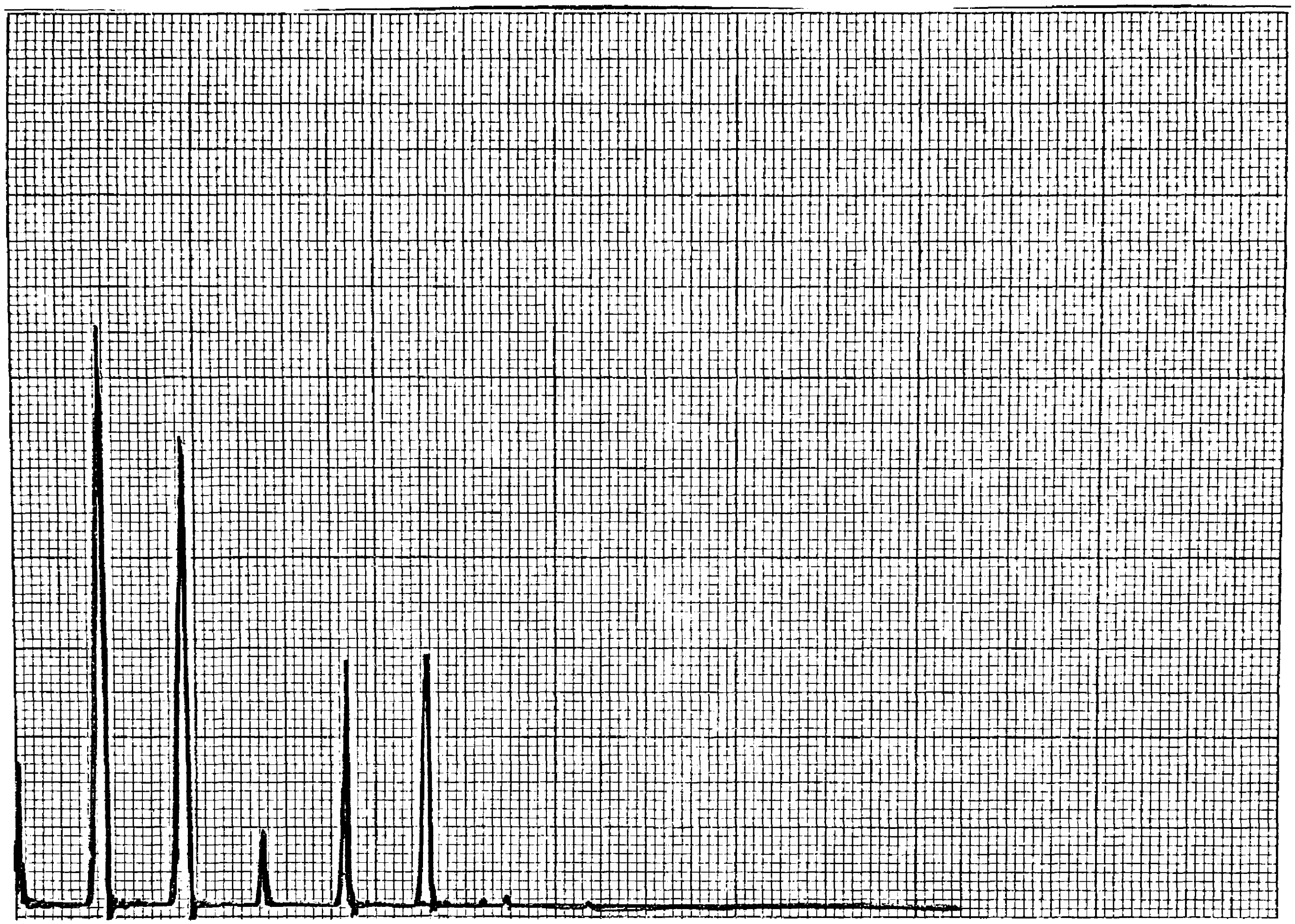
Spectrum Analysis Graph: Group III, Subject Number 44, Pitch d.

Spectrum Analysis Graph: Group III, Subject Number 44, Pitch g.

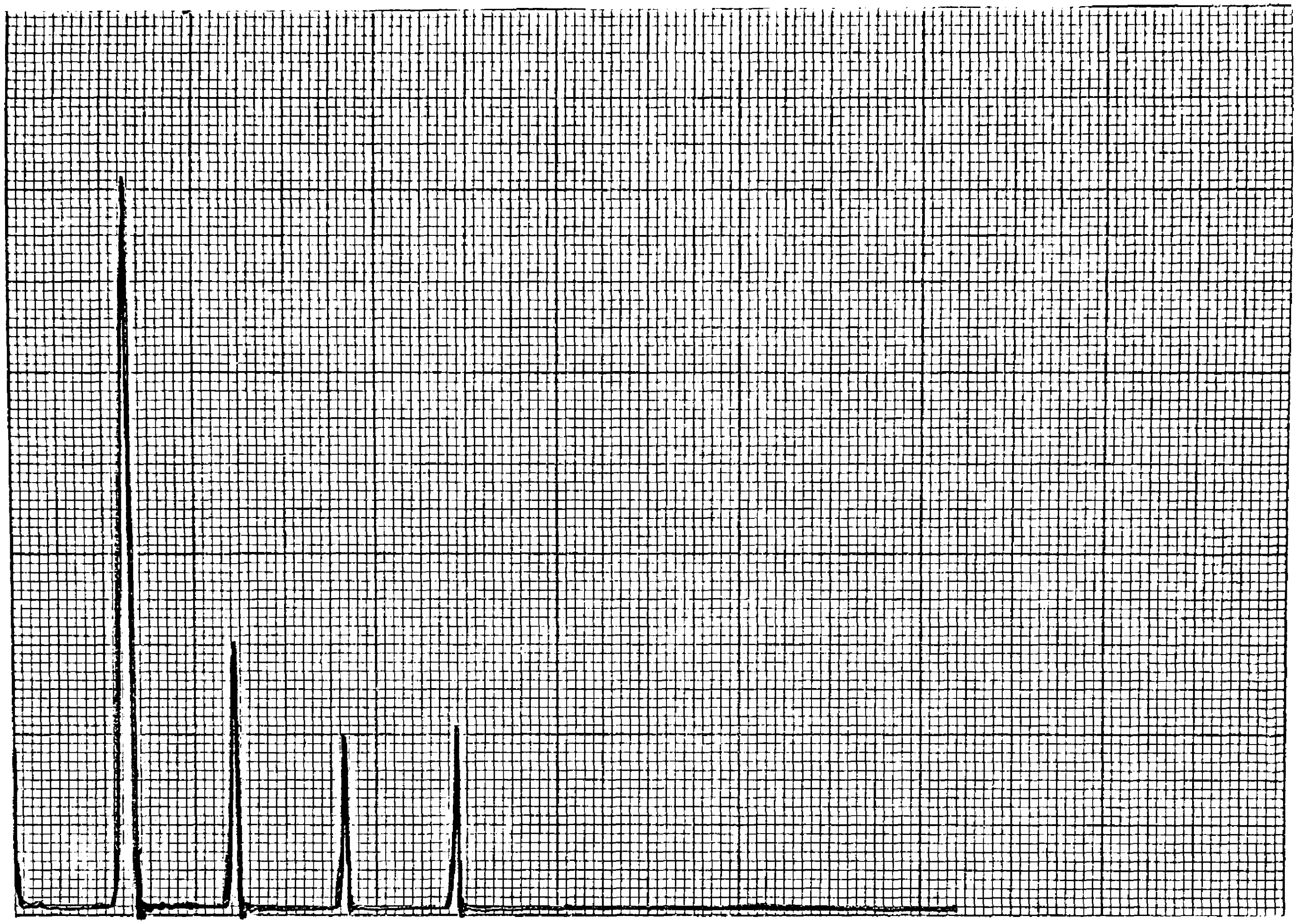
Spectrum Analysis Graph: Group III, Subject Number 44, Pitch c.



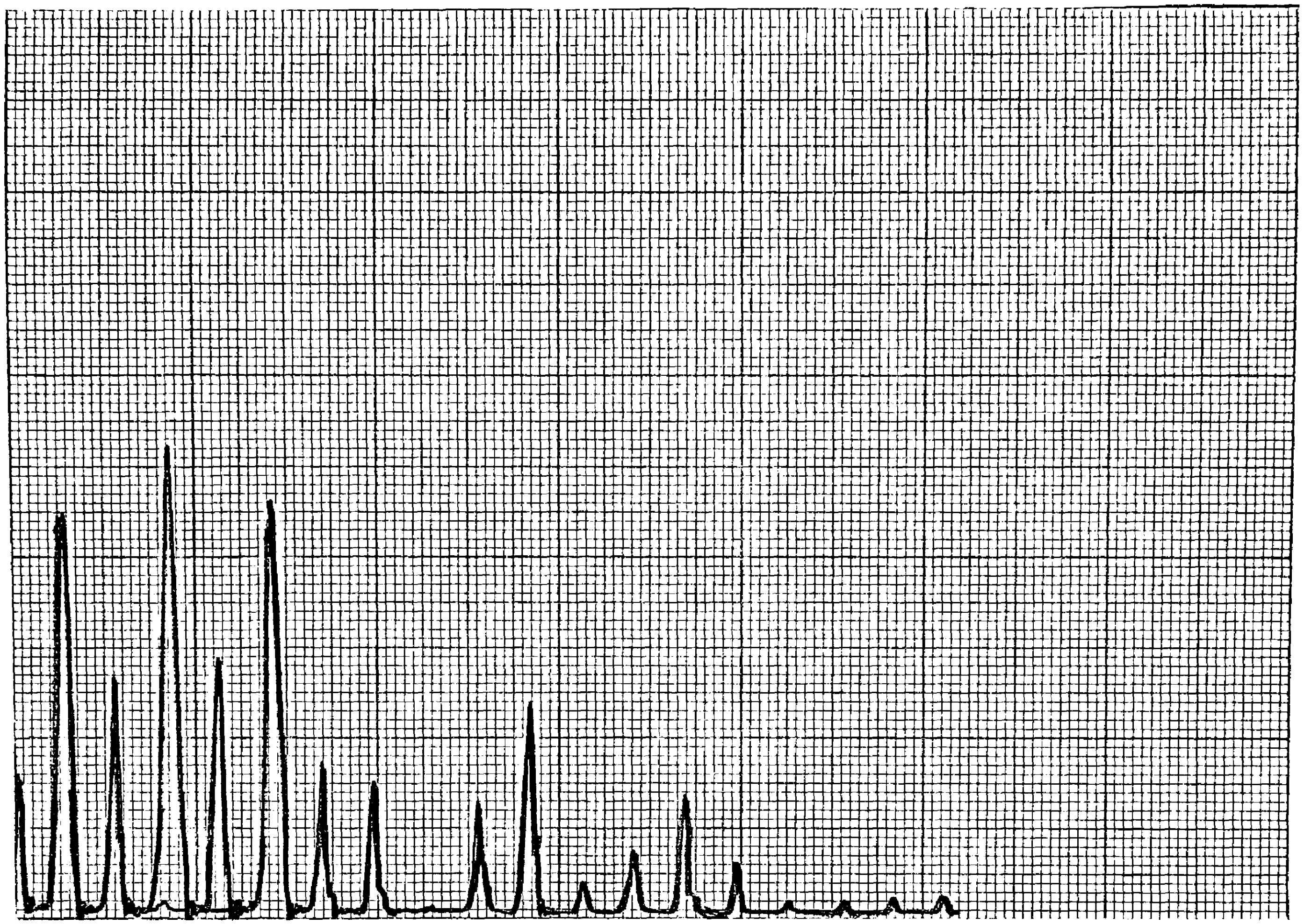
Spectrum Analysis Graph: Group III, Subject Number 44, Pitch f.



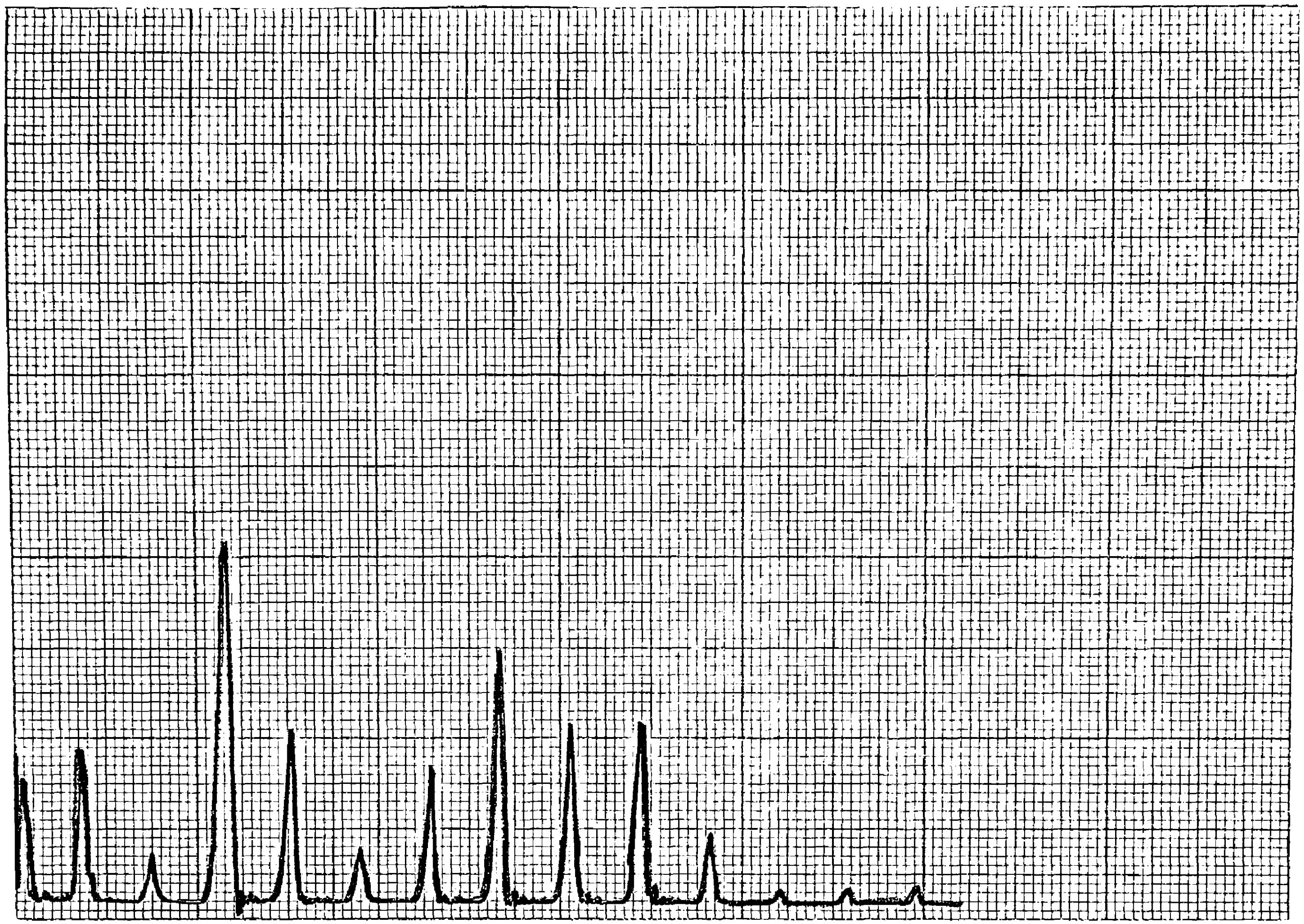
Spectrum Analysis Graph: Group III, Subject Number 44, Pitch b^b.



Spectrum Analysis Graph: Group III, Subject Number 44, Pitch e^{b}.

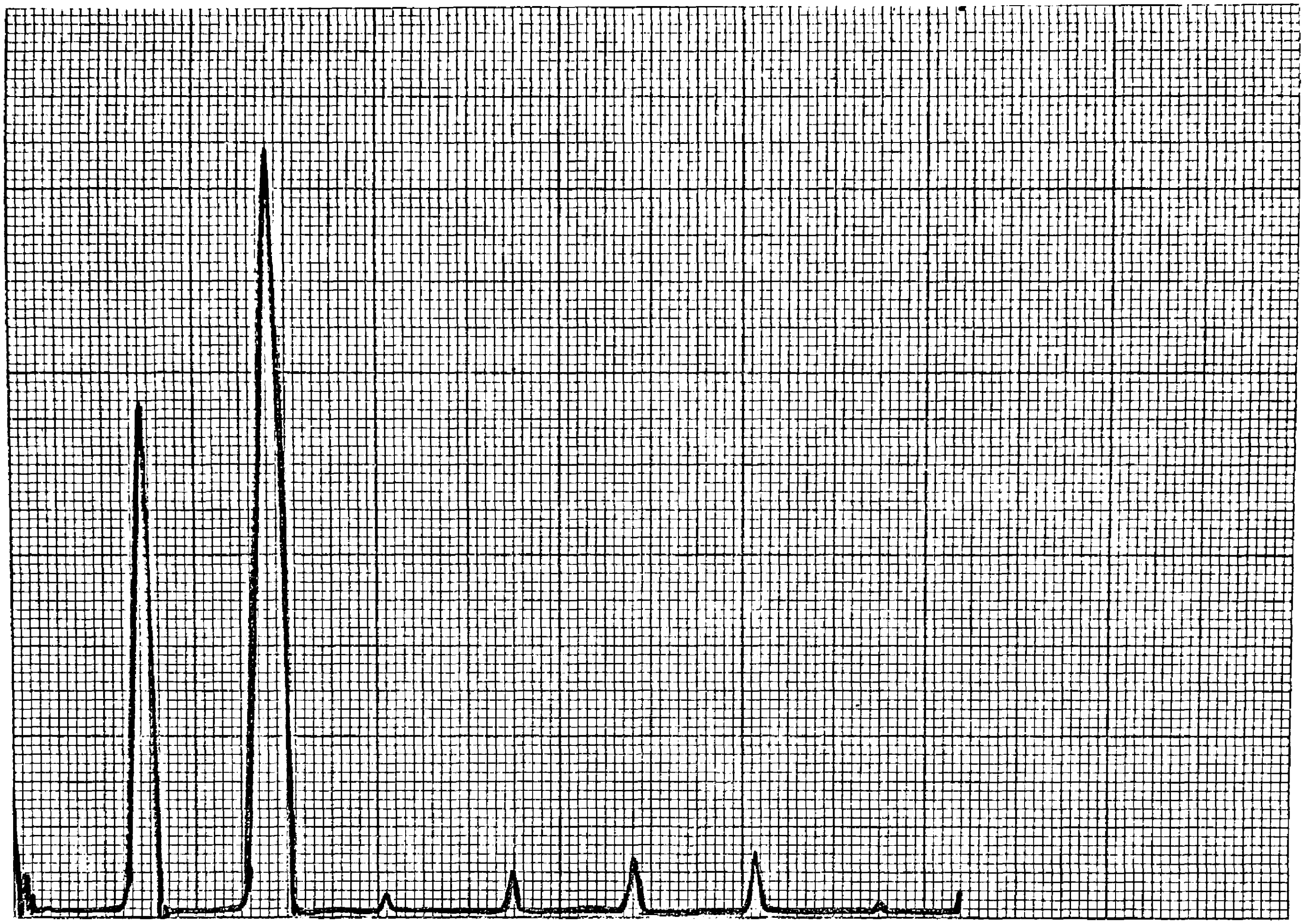


Spectrum Analysis Graph: Group III, Subject Number 45, Pitch d.

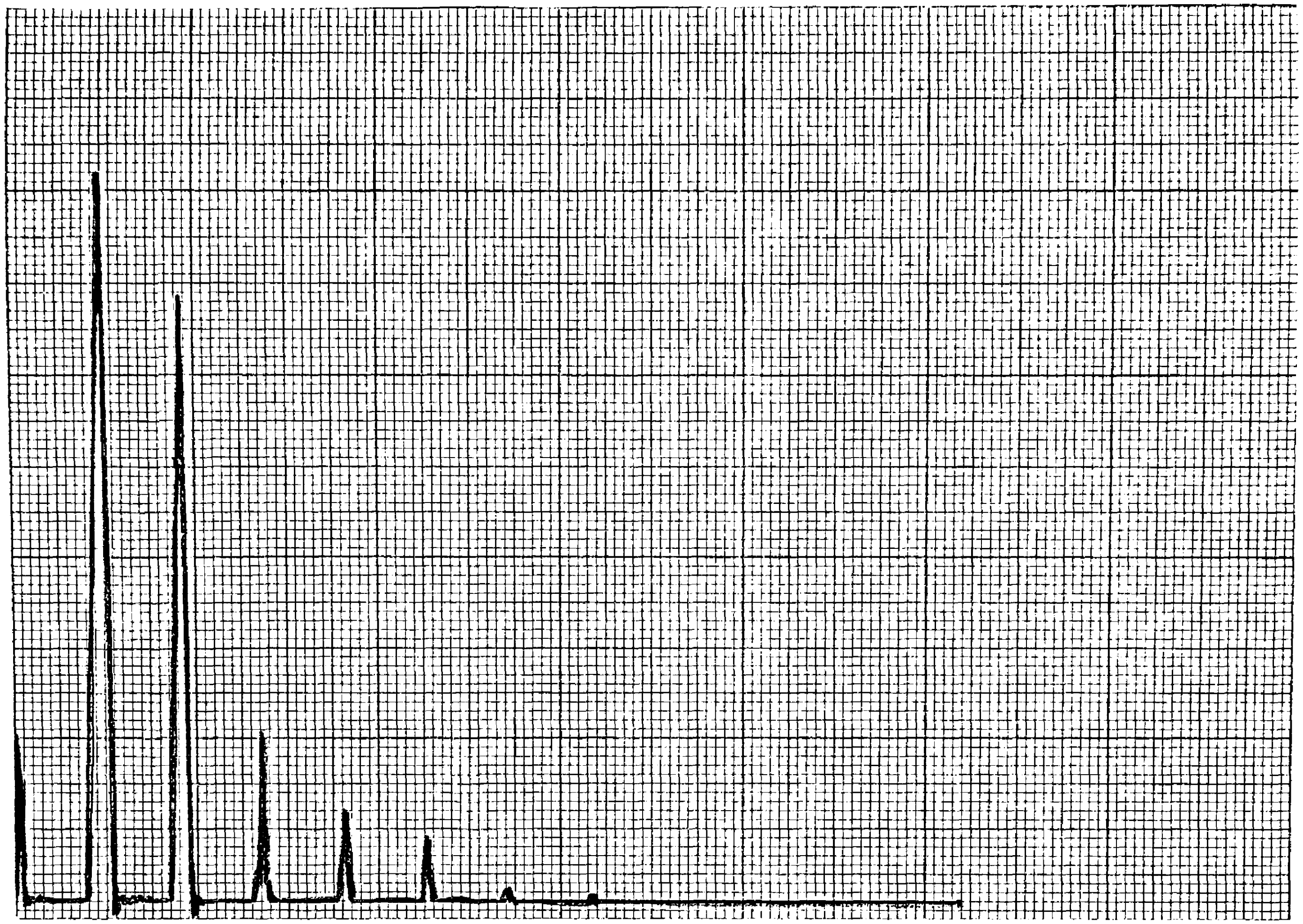


Spectrum Analysis Graph: Group III, Subject Number 45, Pitch g.

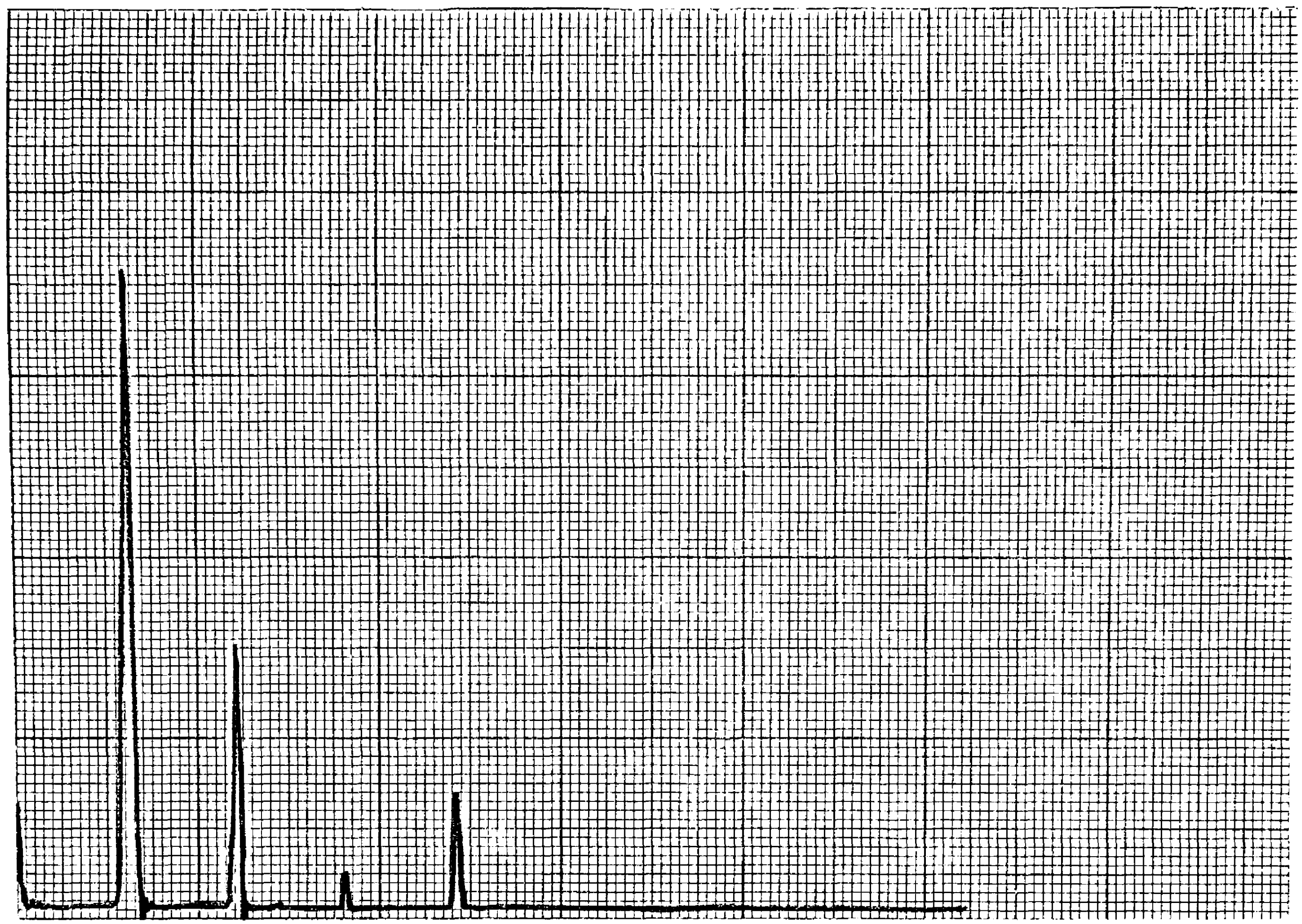
Spectrum Analysis Graph: Group III, Subject Number 45, Pitch c.



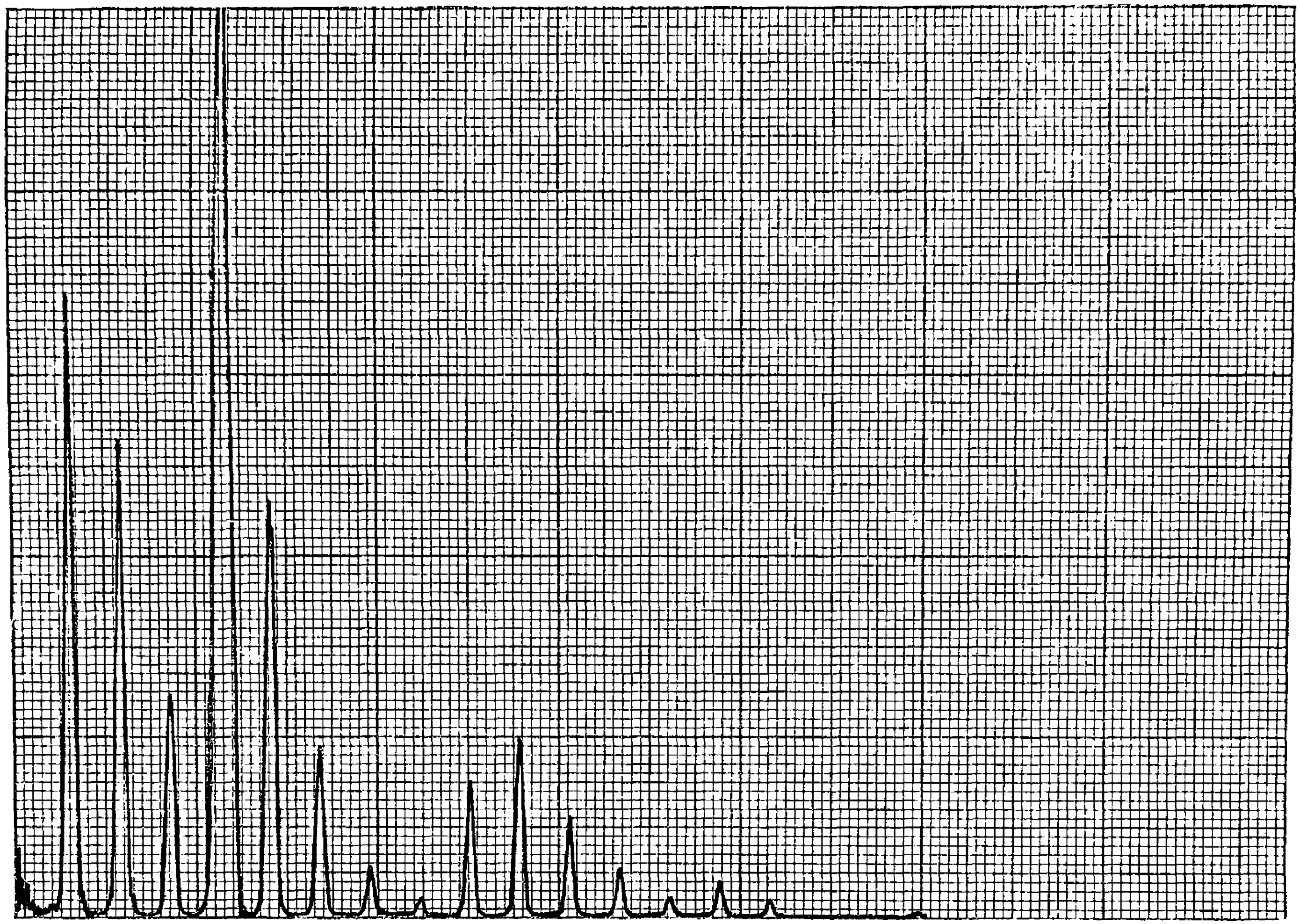
Spectrum Analysis Graph: Group III, Subject Number 45, Pitch f.



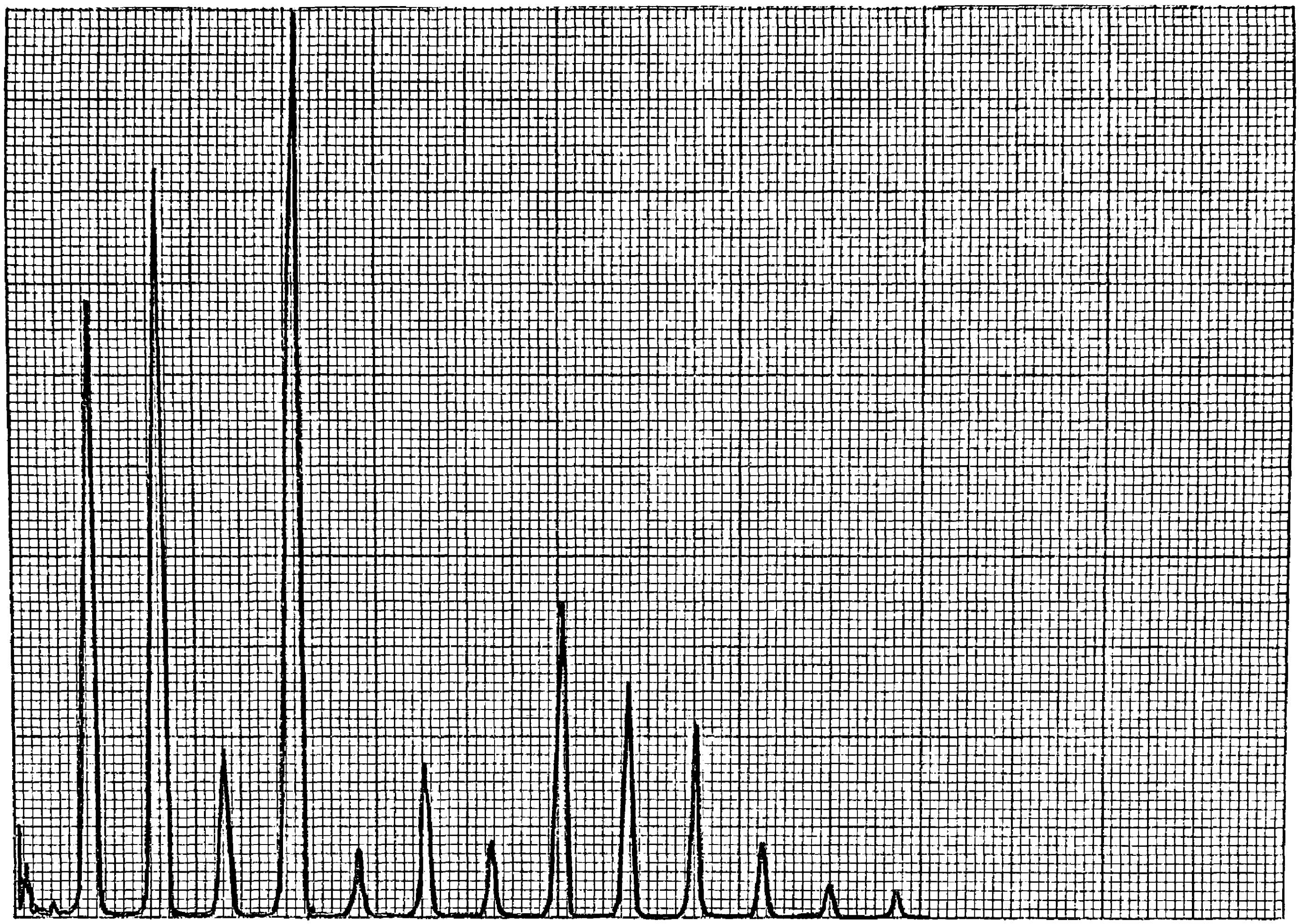
Spectrum Analysis Graph: Group III, Subject Number 45, Pitch b^b.



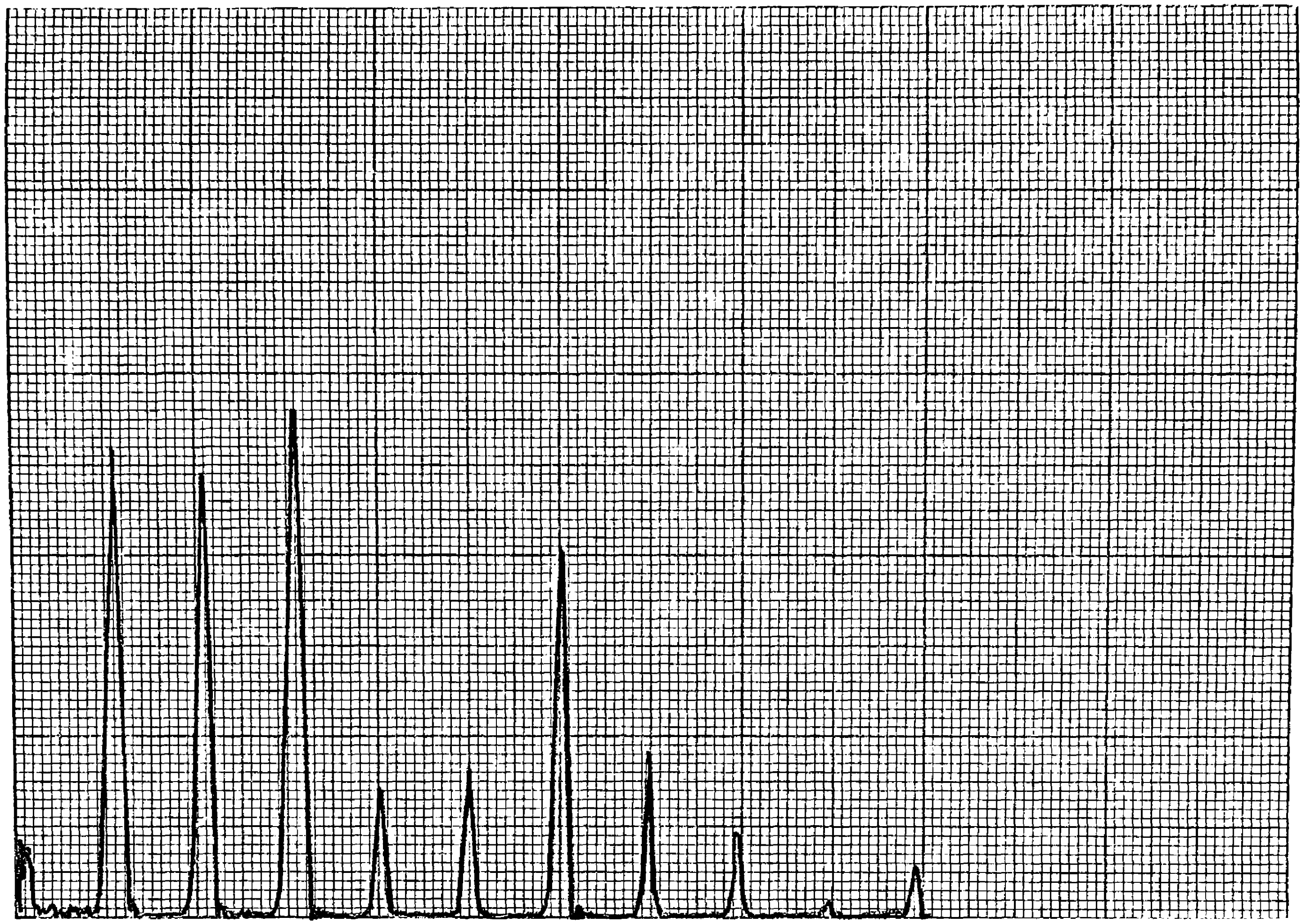
Spectrum Analysis Graph: Group III, Subject Number 45, Pitch e^{b}.



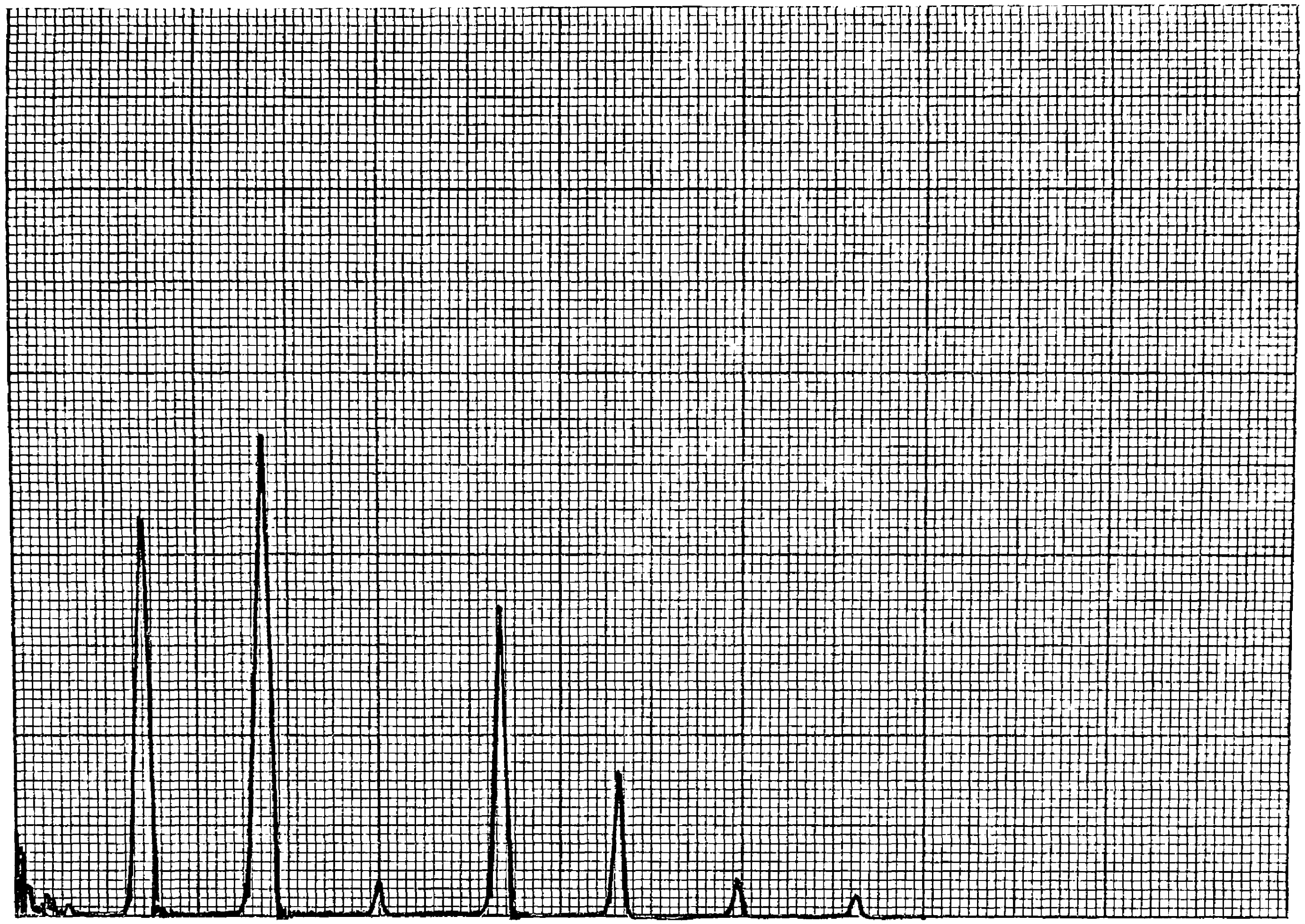
Spectrum Analysis Graph: Group IV, Subject Number 10, Pitch d.



Spectrum Analysis Graph: Group IV, Subject Number 10, Pitch g.

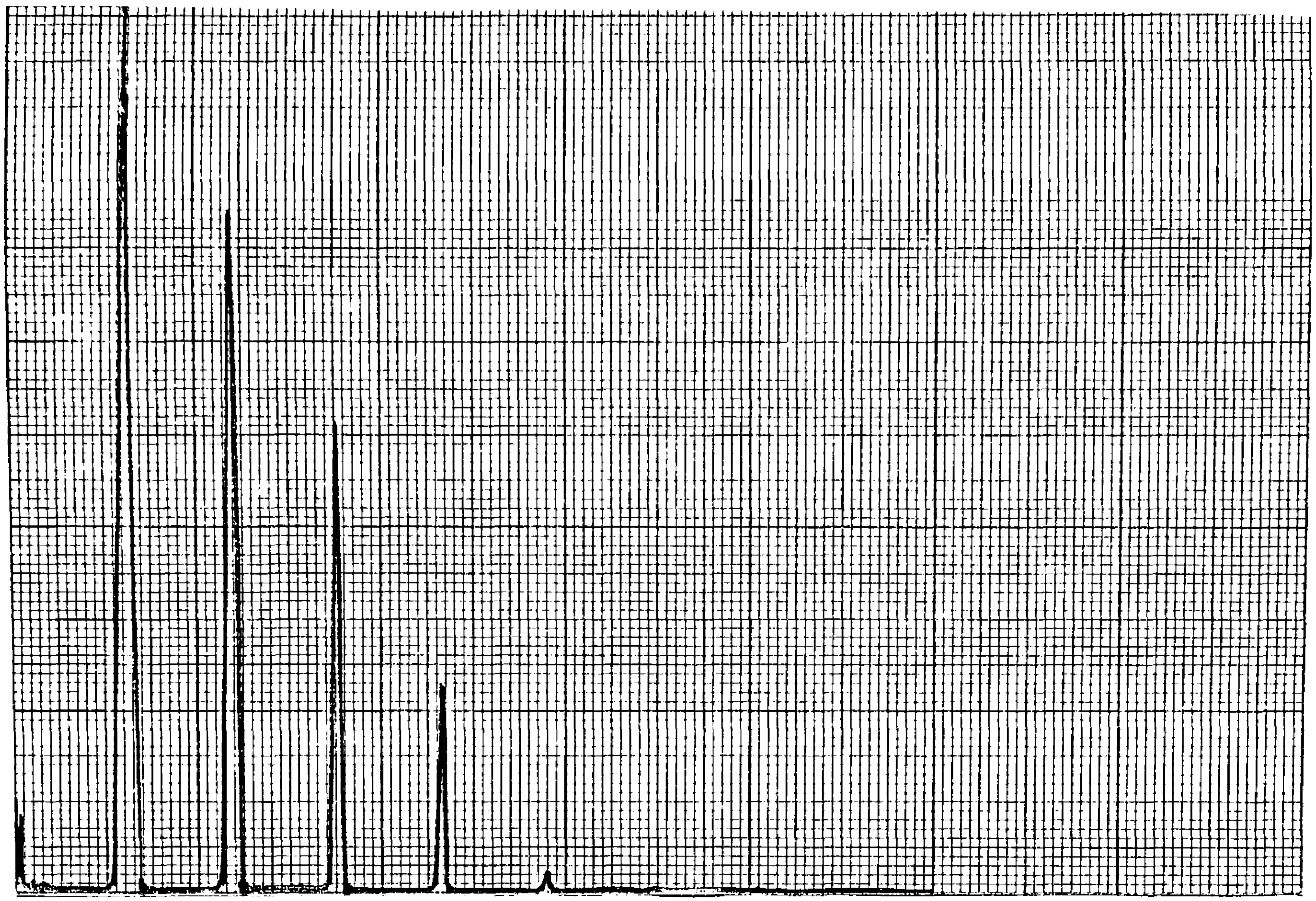


Spectrum Analysis Graph: Group IV, Subject Number 10, Pitch c.

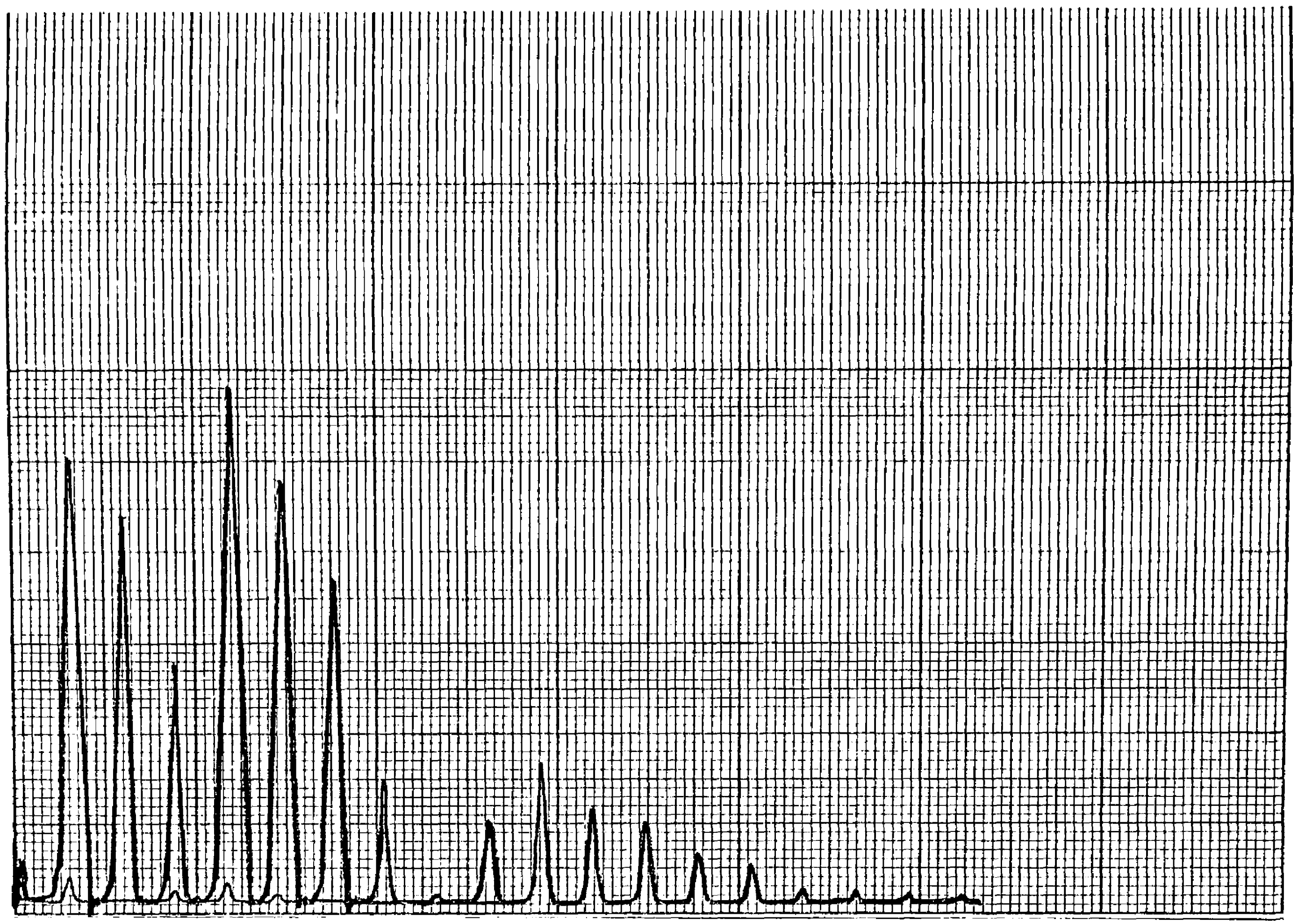


Spectrum Analysis Graph: Group IV, Subject Number 10, Pitch f.

Spectrum Analysis Graph: Group IV, Subject Number 10, Pitch b^b.



Spectrum Analysis Graph: Group IV, Subject Number 10, Pitch e^b.



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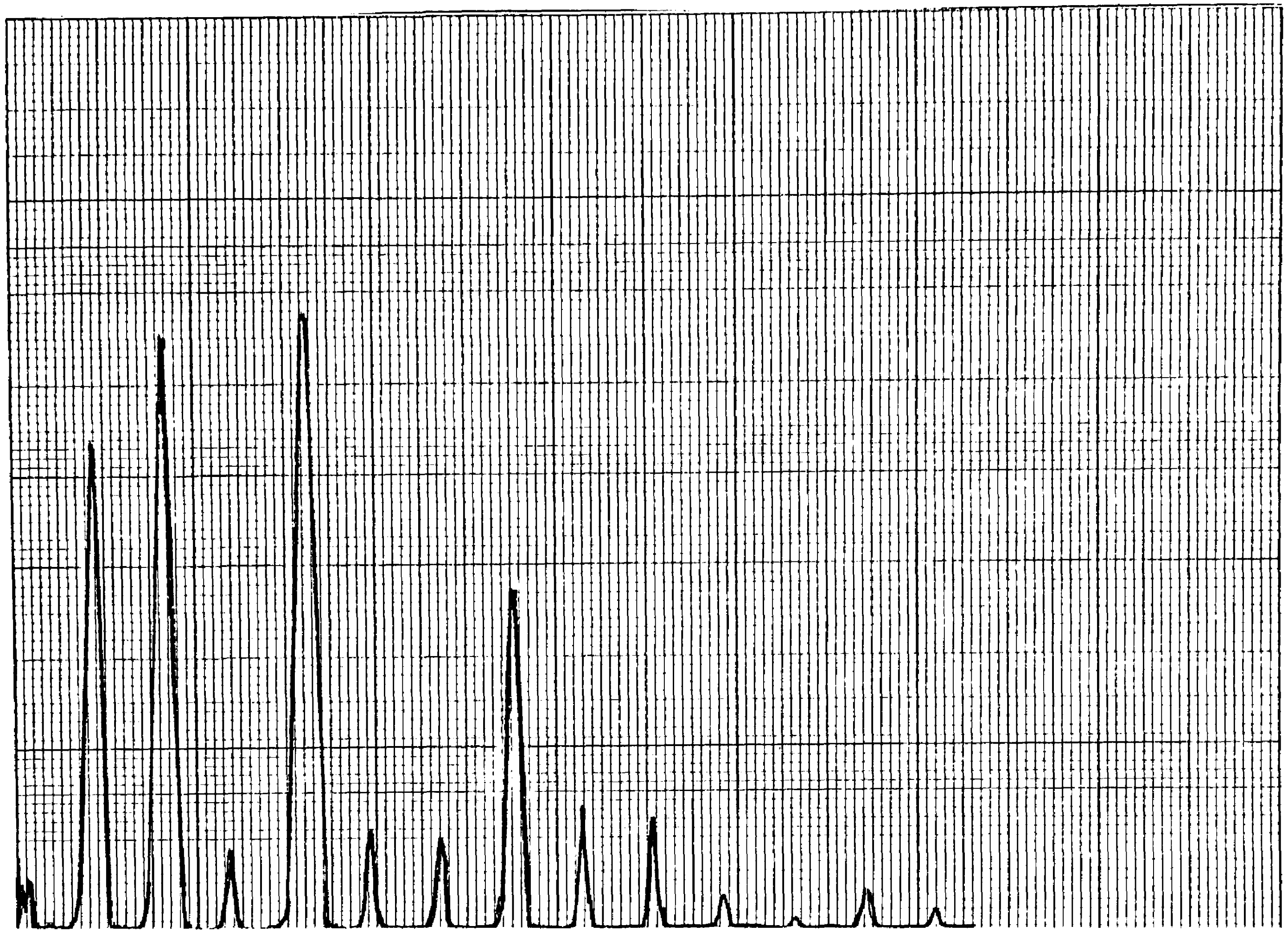
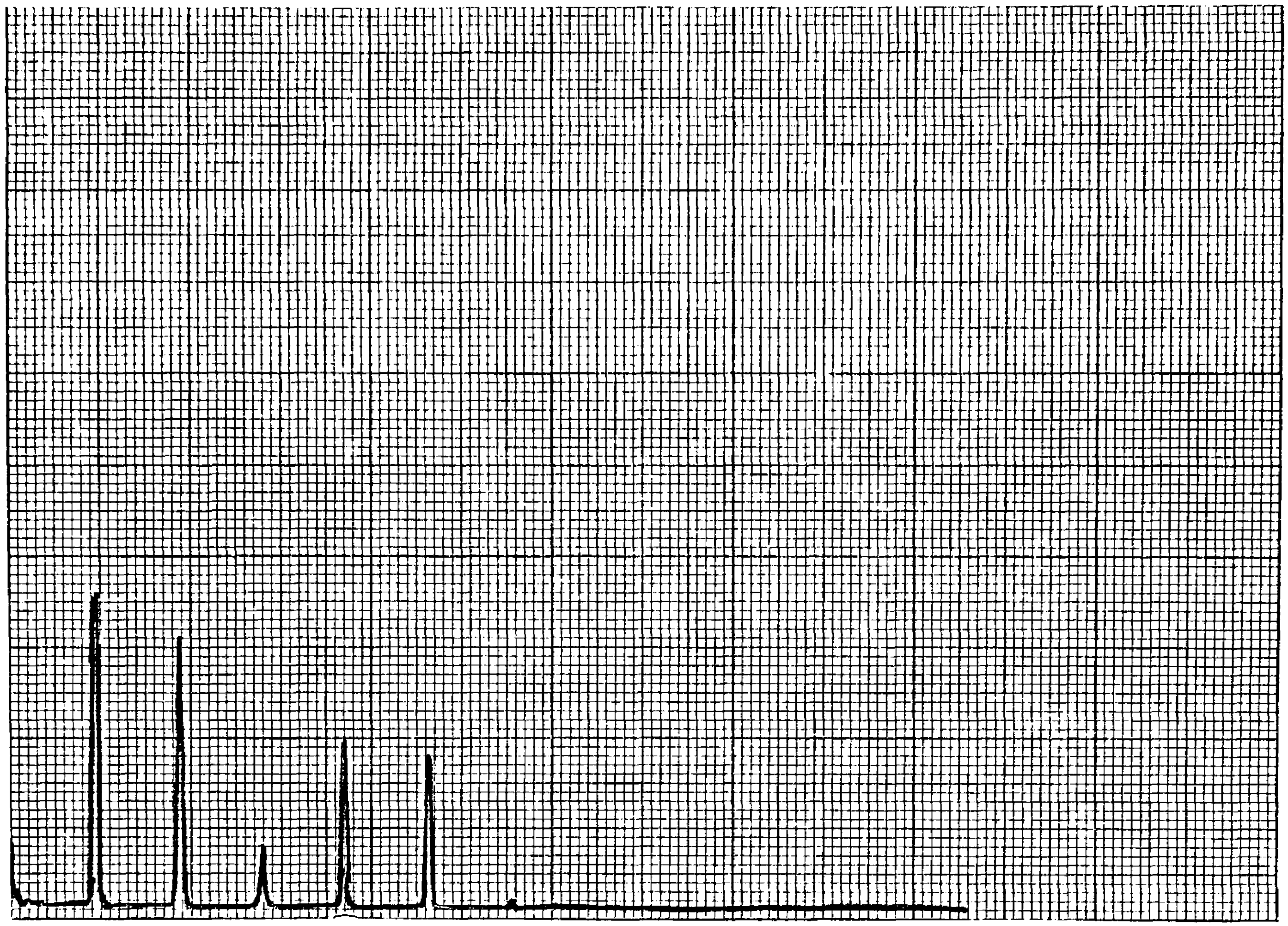


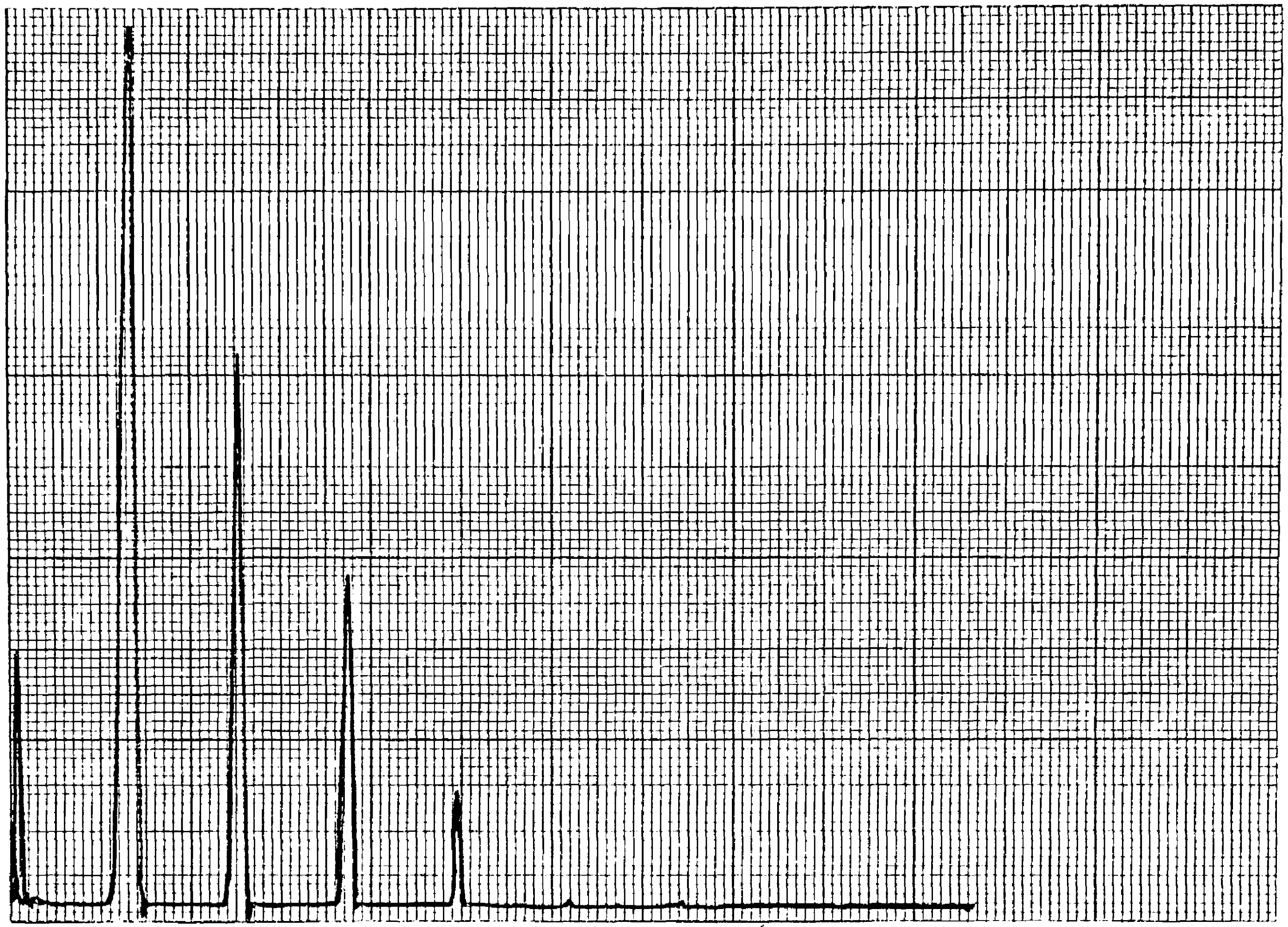
Spectrum Analysis Graph: Group IV, Subject Number 11, Pitch g.

Spectrum Analysis Graph: Group IV, Subject Number 11, Pitch c.

Spectrum Analysis Graph: Group IV, Subject Number 11, Pitch f.



Spectrum Analysis Graph: Group IV, Subject Number 11, Pitch b^{b}.



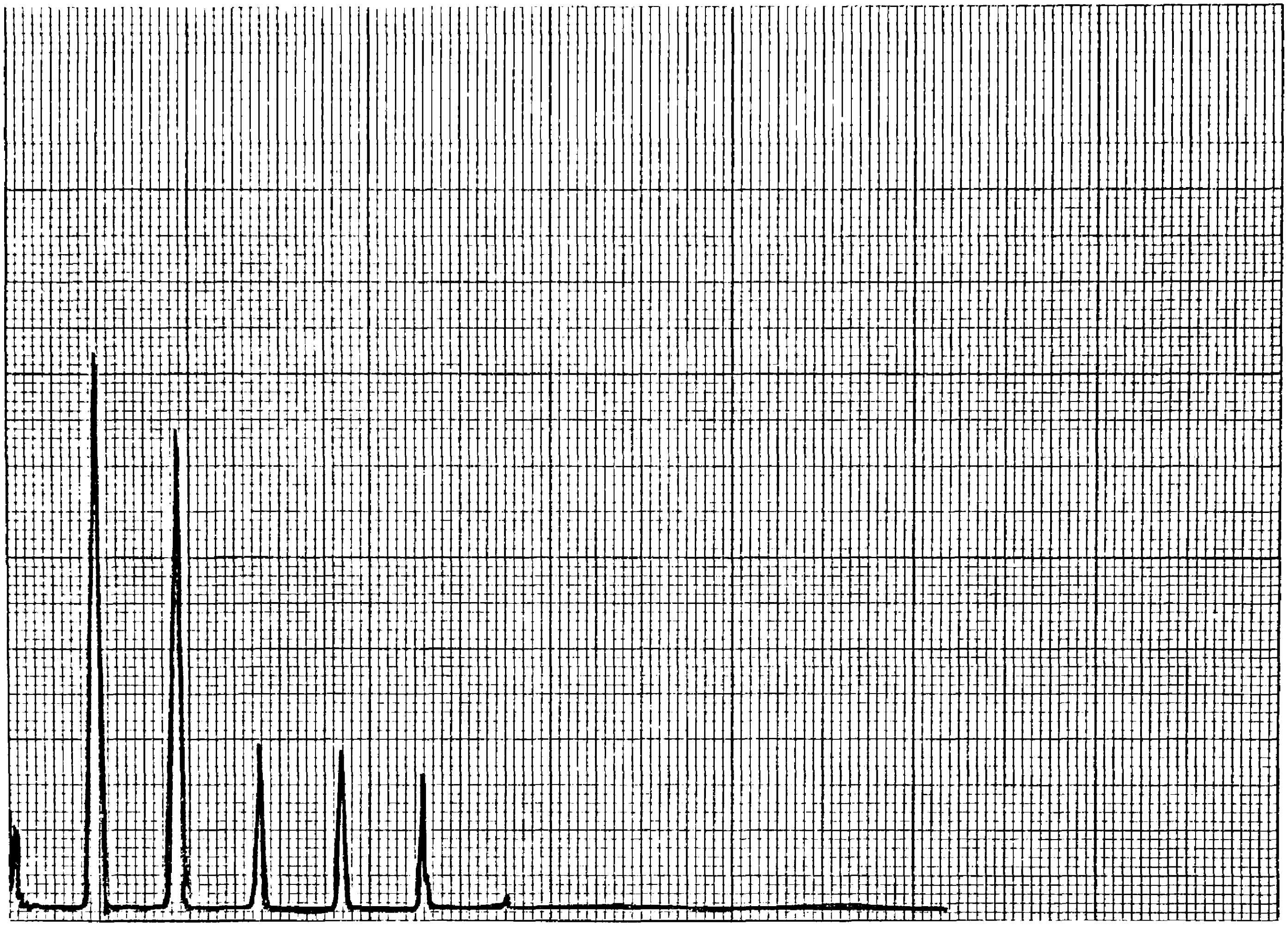
Spectrum Analysis Graph: Group IV, Subject Number 11, Pitch e^{b}.

Spectrum Analysis Graph: Group IV, Subject Number 12, Pitch d.

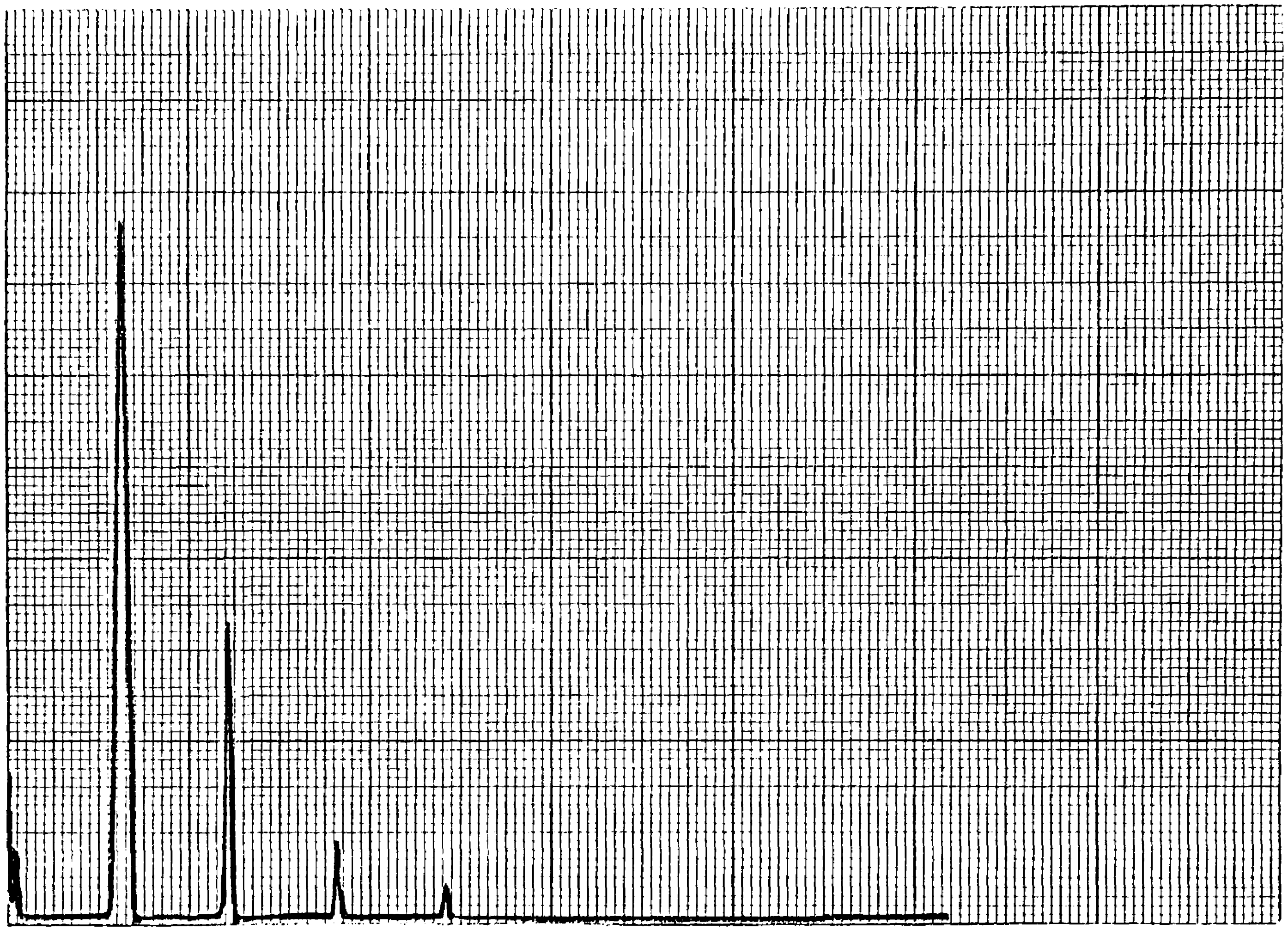
Spectrum Analysis Graph: Group IV, Subject Number 12, Pitch g.

Spectrum Analysis Graph: Group IV, Subject Number 12, Pitch c.

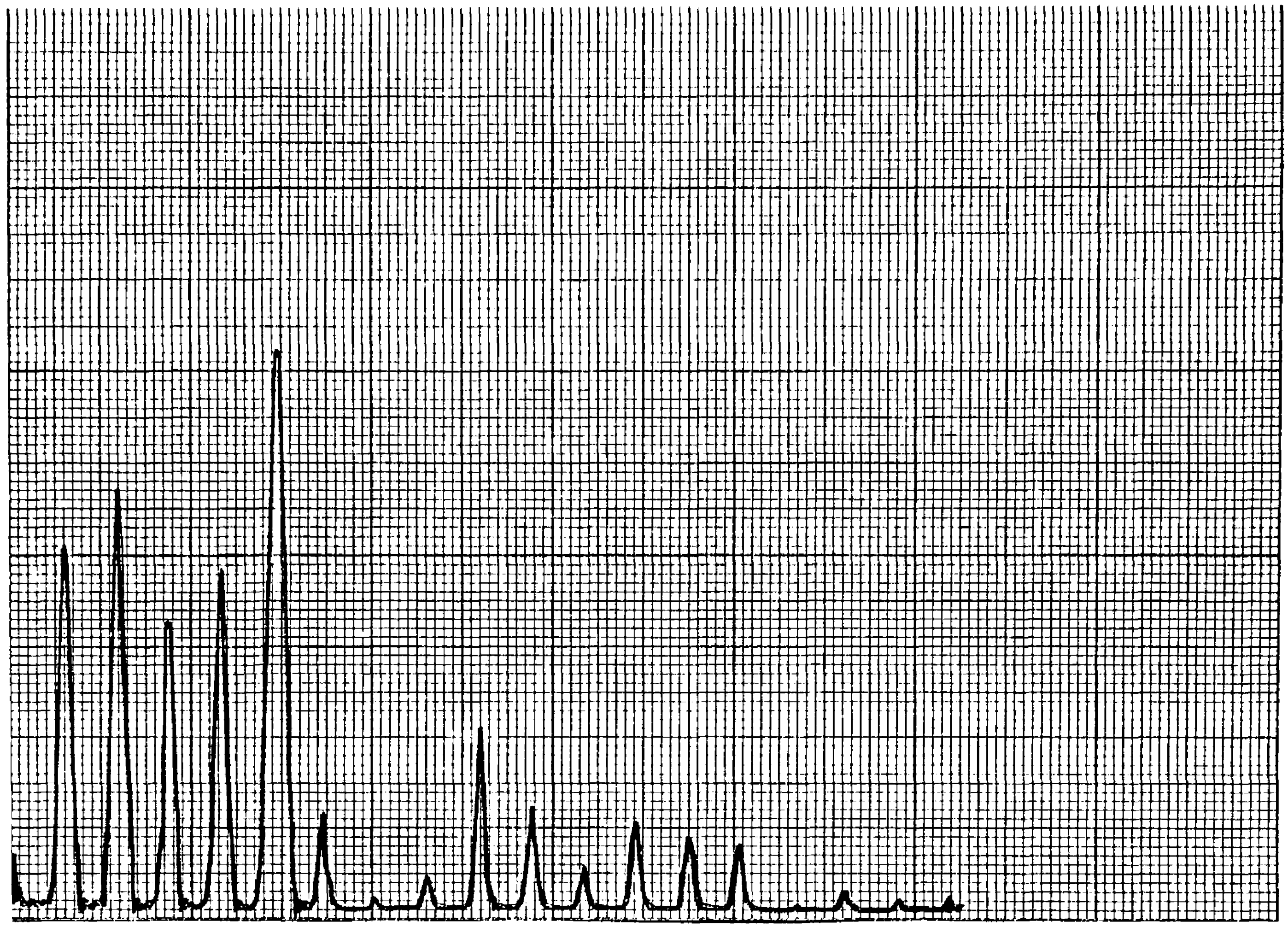
Spectrum Analysis Graph: Group IV, Subject Number 12, Pitch f.



Spectrum Analysis Graph: Group IV, Subject Number 12, Pitch b^b.

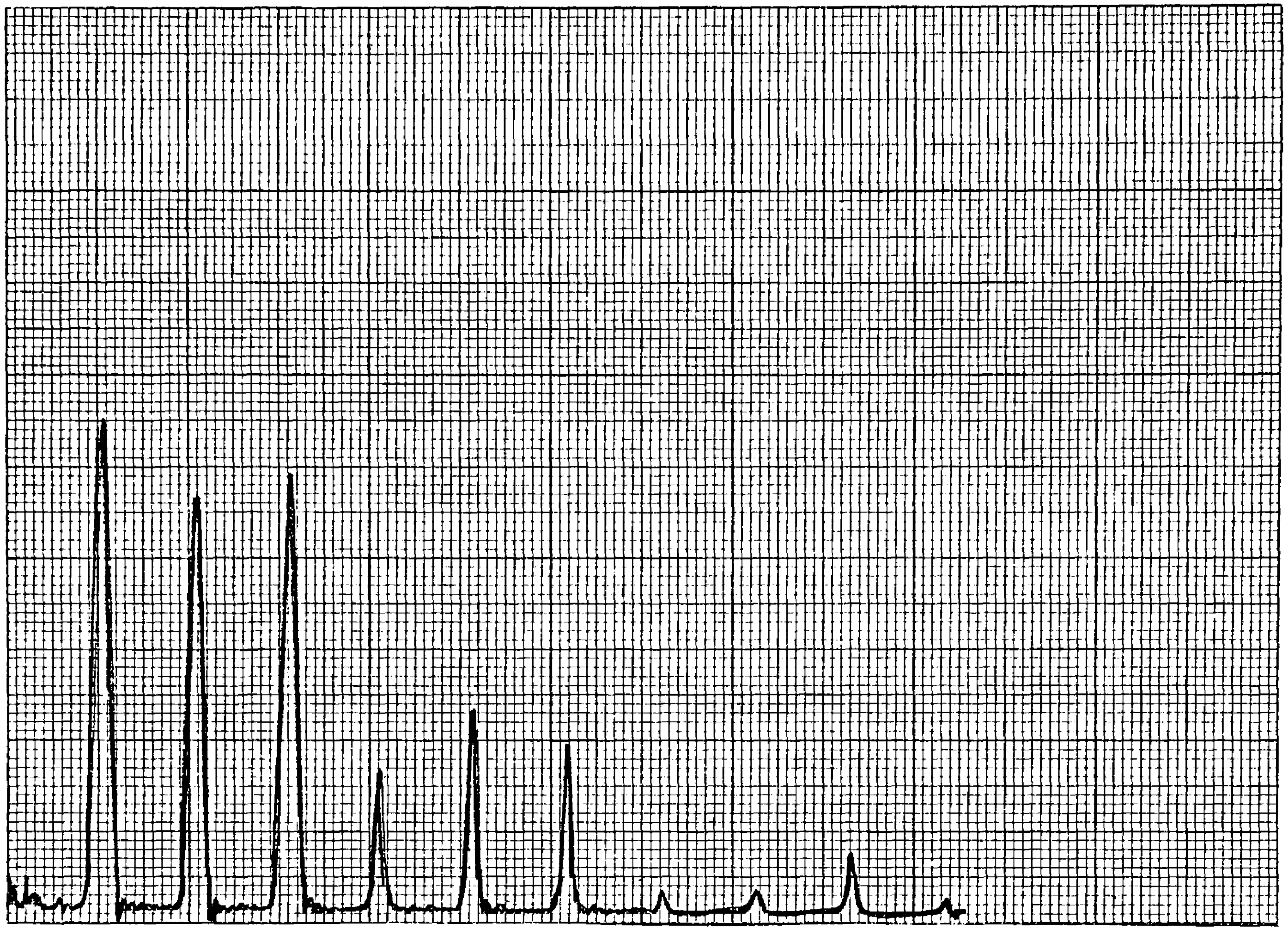


Spectrum Analysis Graph: Group IV, Subject Number 12, Pitch e^{b}.



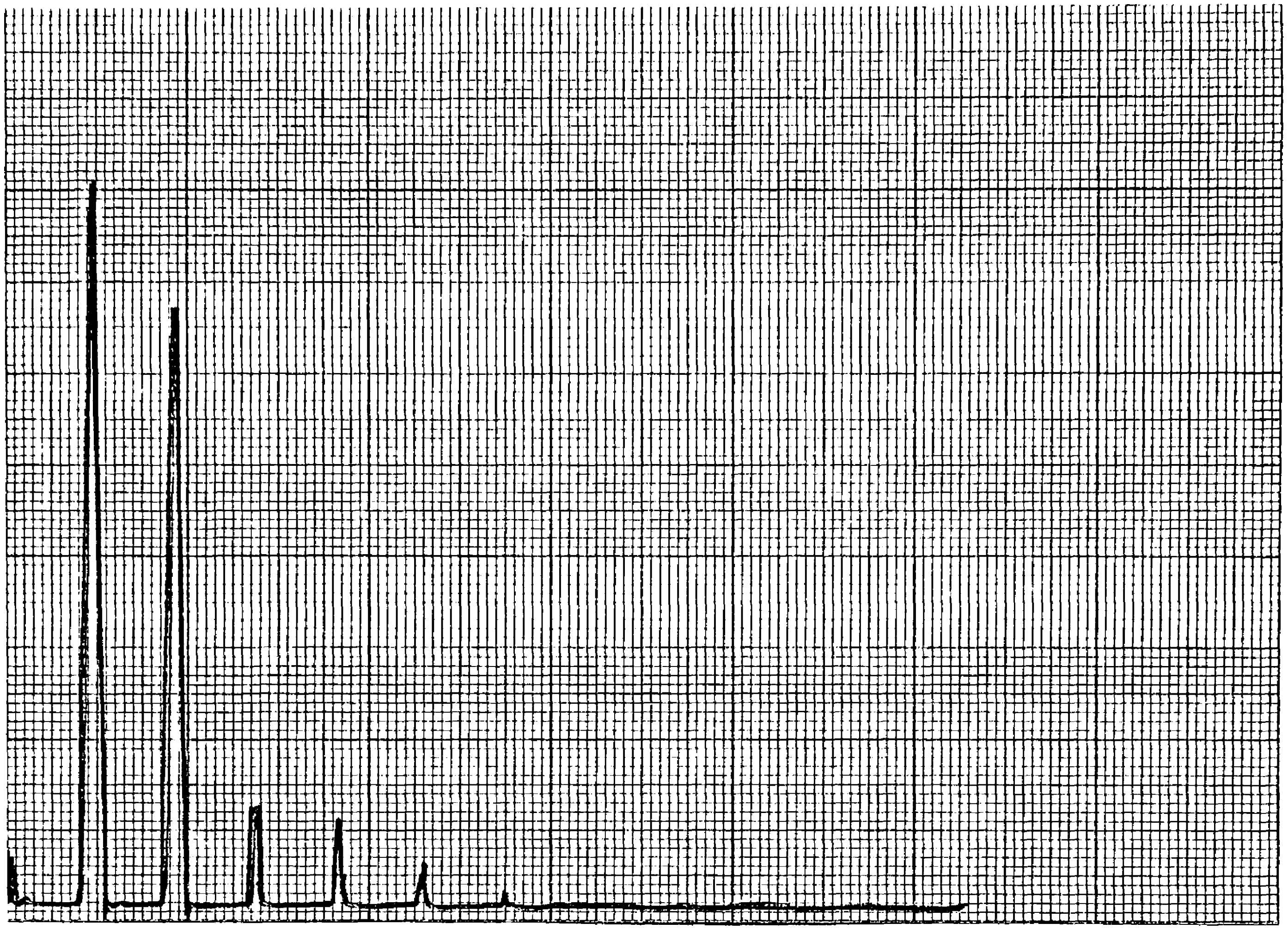
Spectrum Analysis Graph: Group IV, Subject Number 22, Pitch d.

Spectrum Analysis Graph: Group IV, Subject Number 22, Pitch g.

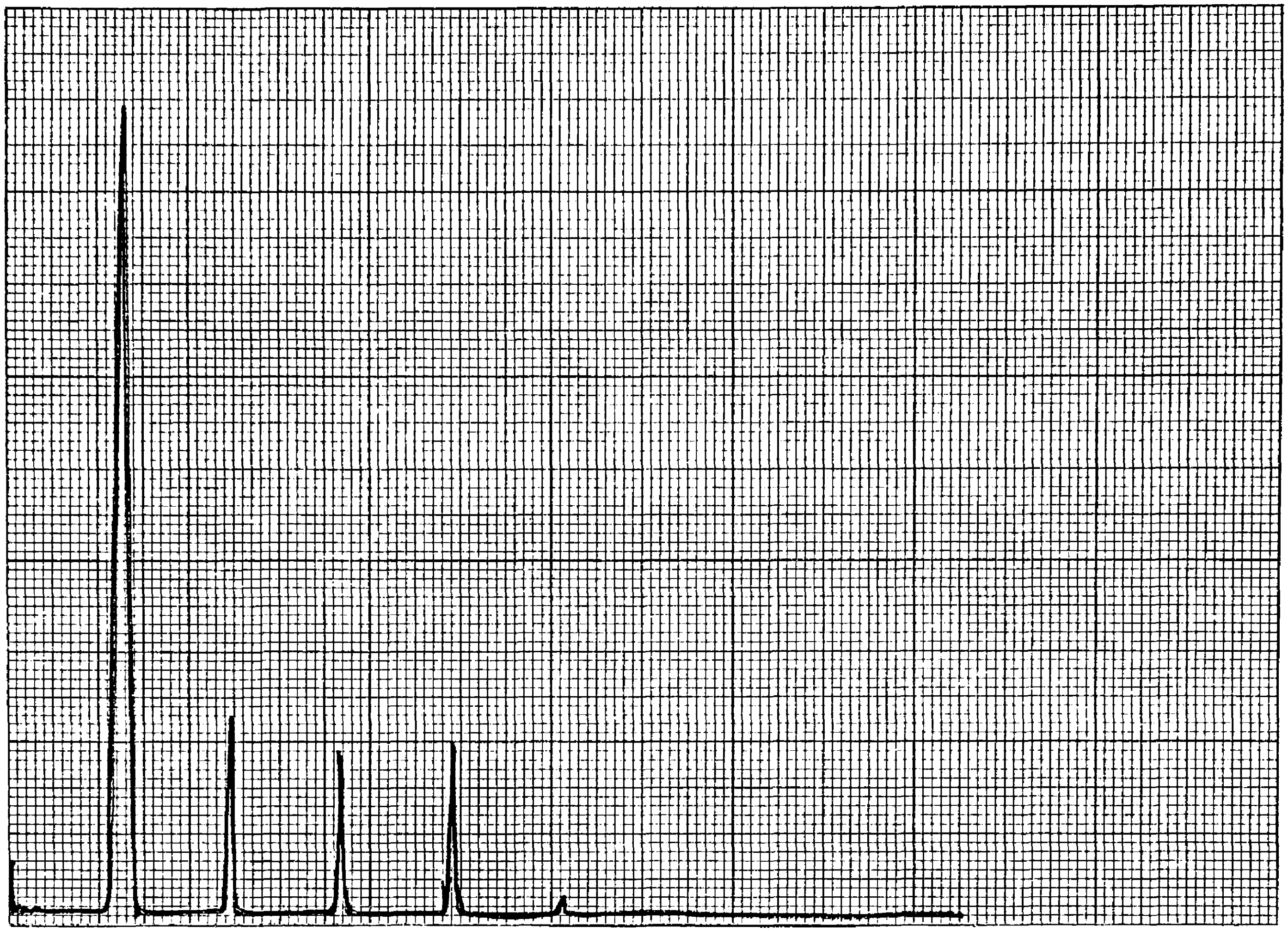


Spectrum Analysis Graph: Group IV, Subject Number 22, Pitch c.

Spectrum Analysis Graph: Group IV, Subject Number 22, Pitch f.

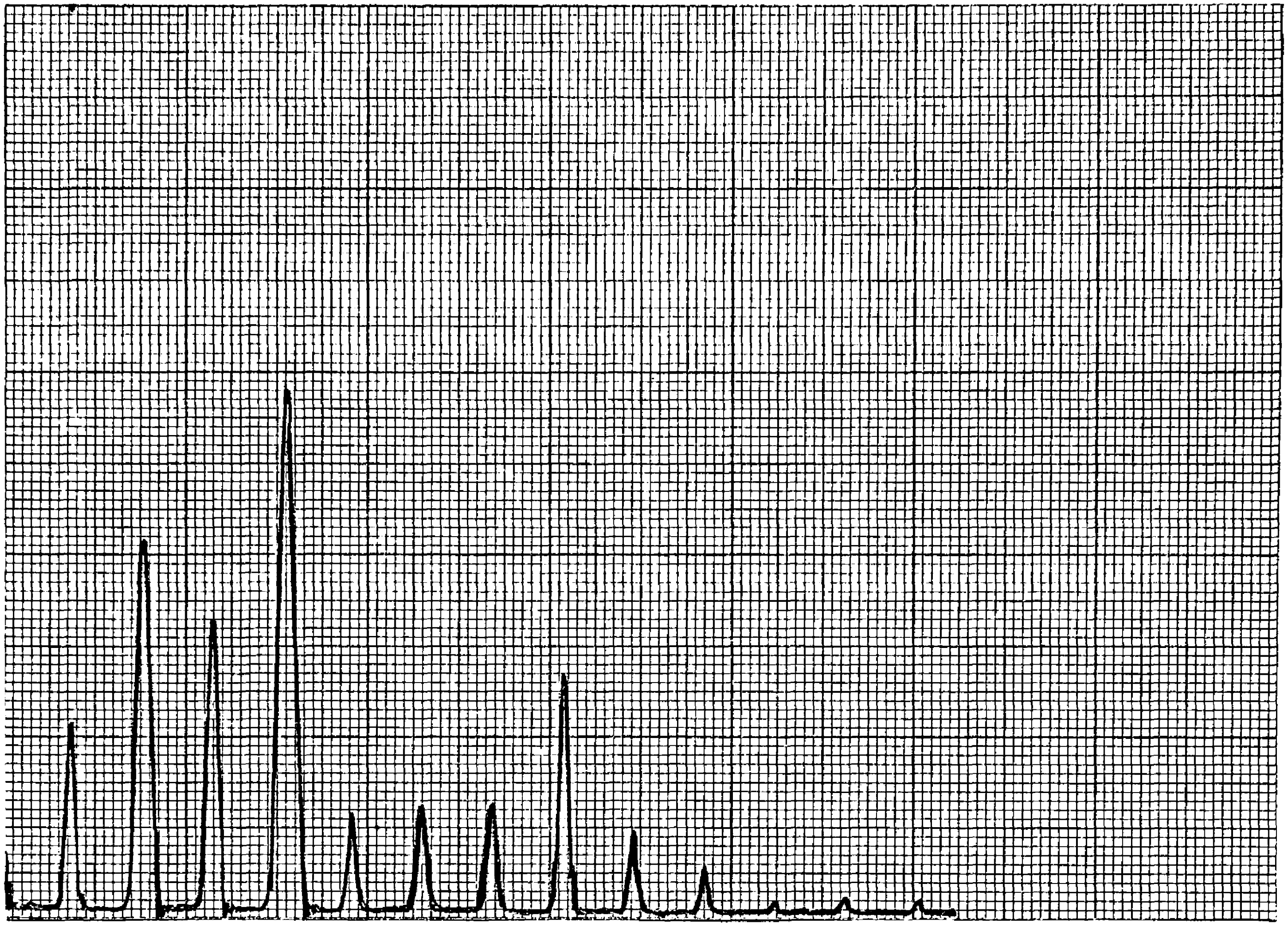


Spectrum Analysis Graph: Group IV, Subject Number 22, Pitch b^b.

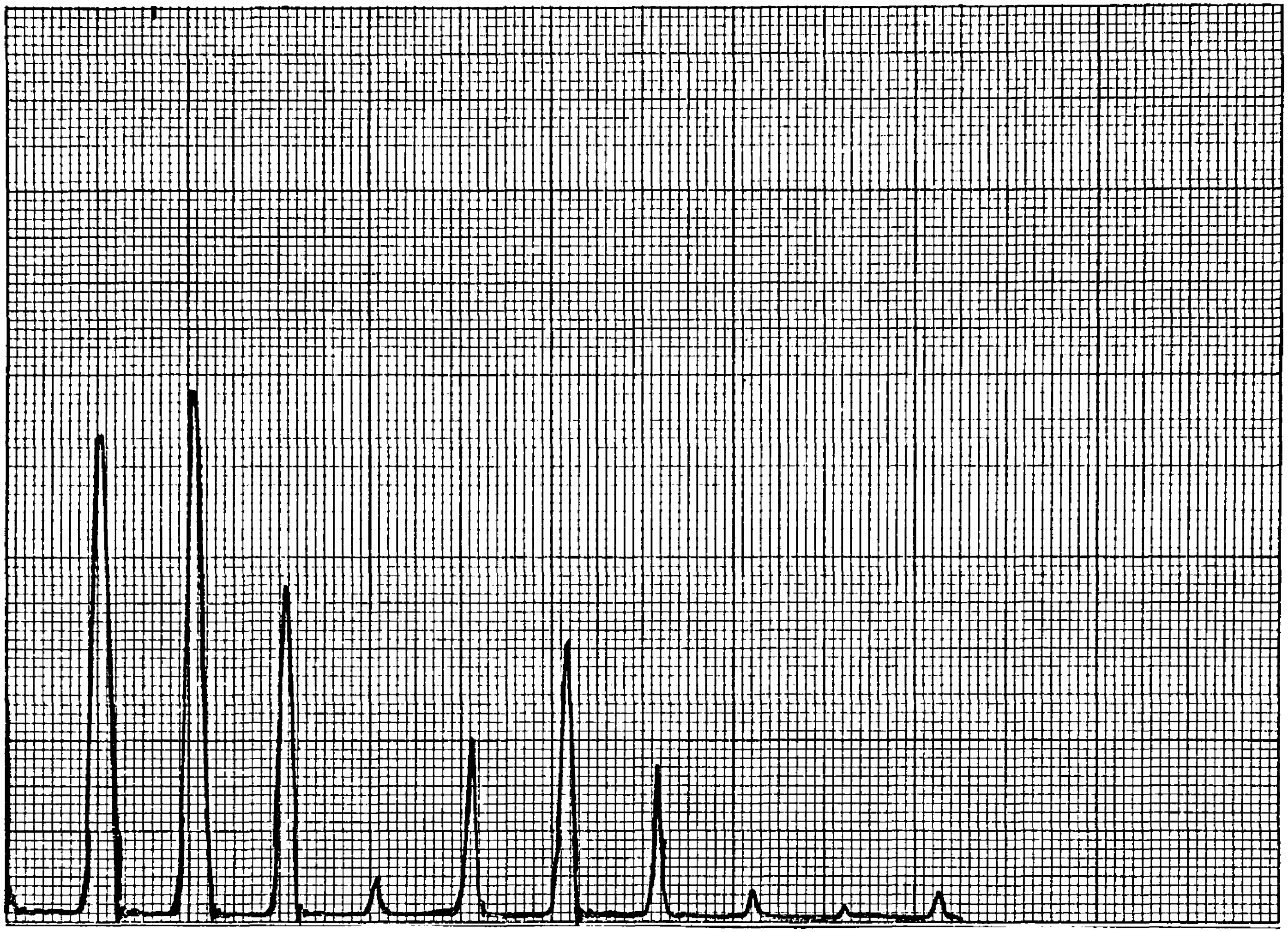


Spectrum Analysis Graph: Group IV, Subject Number 22, Pitch e^b.

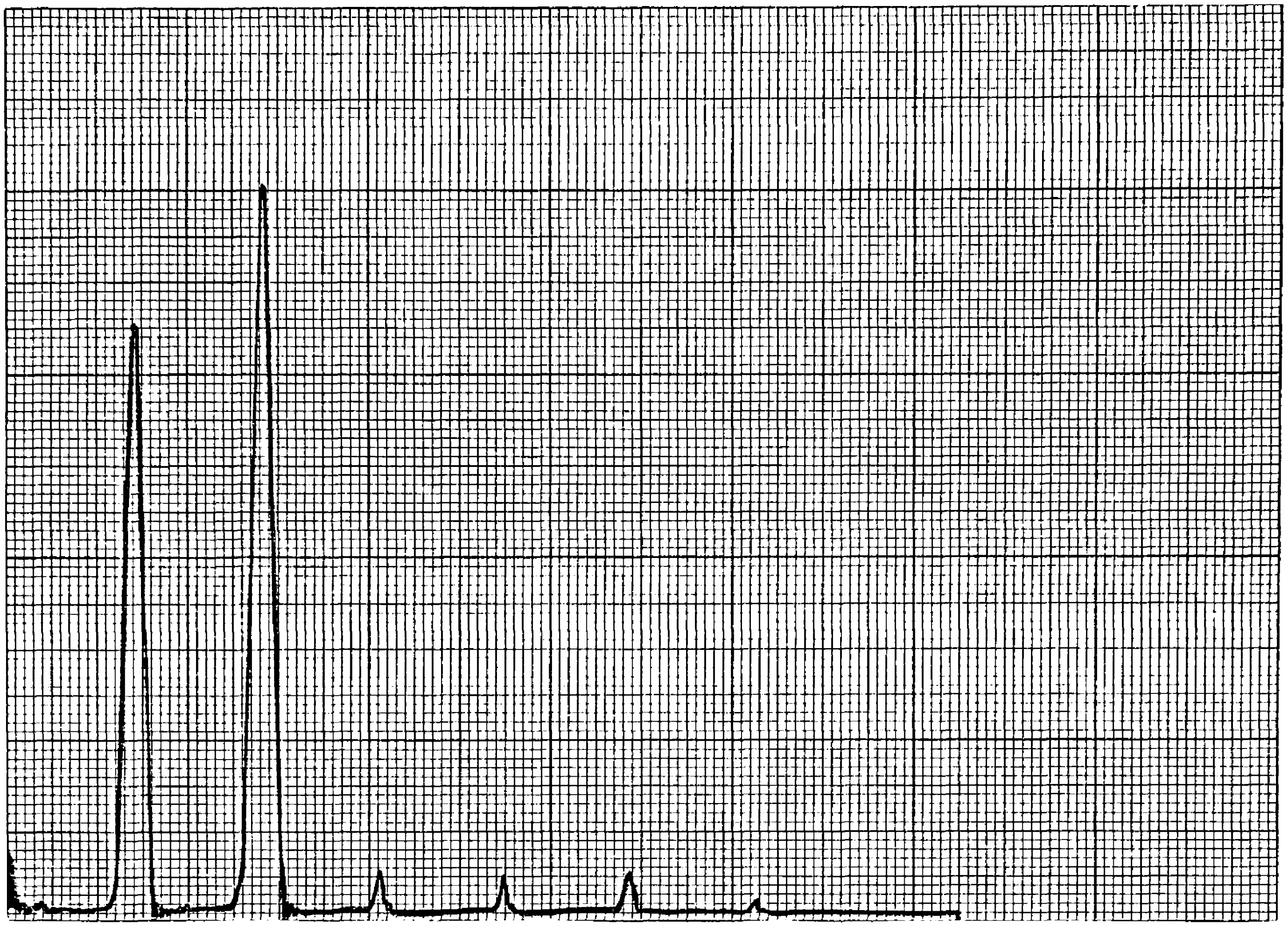
Spectrum Analysis Graph: Group IV, Subject Number 23, Pitch d.



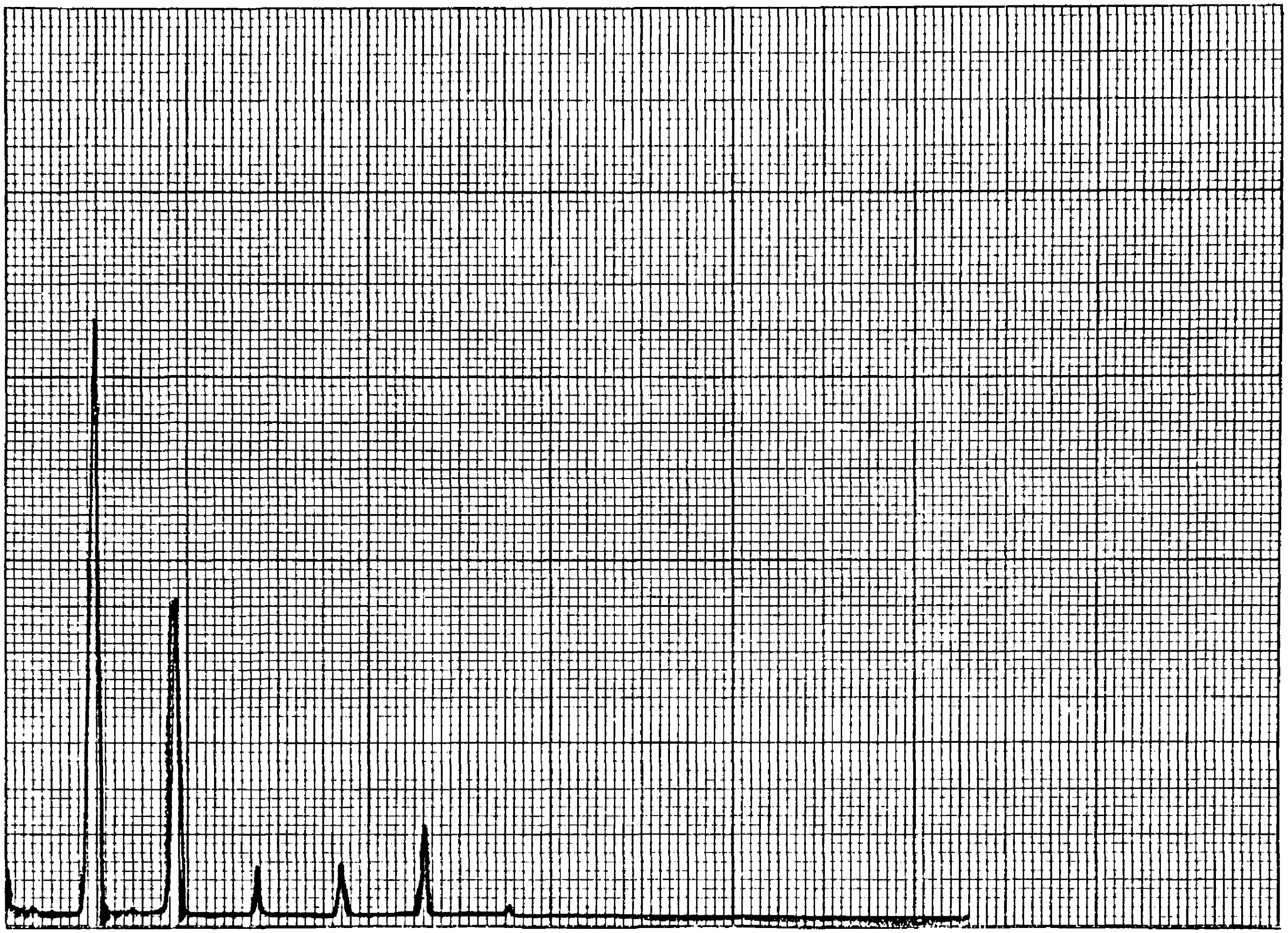
Spectrum Analysis Graph: Group IV, Subject Number 23, Pitch g.



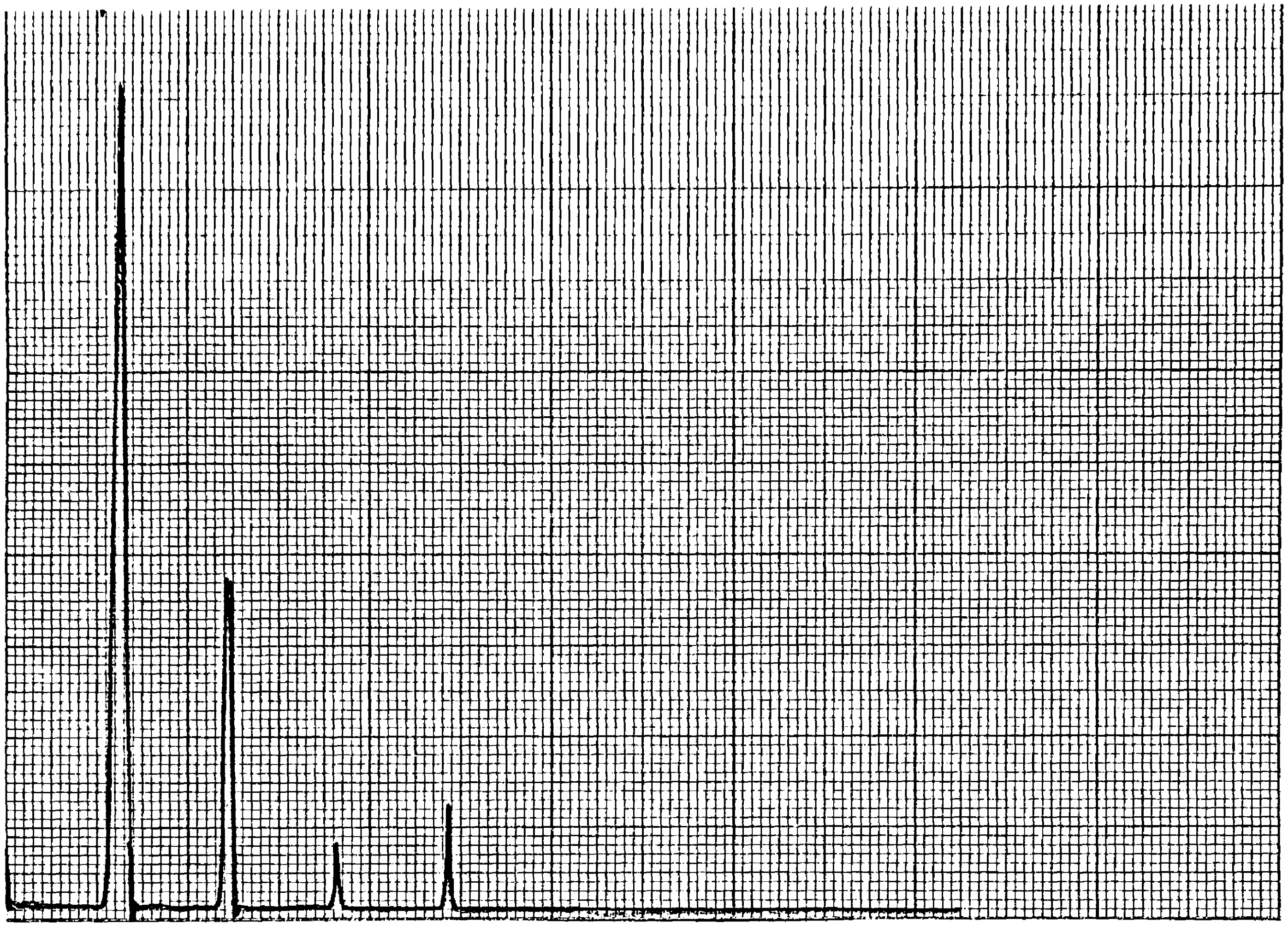
Spectrum Analysis Graph: Group IV, Subject Number 23, Pitch c.



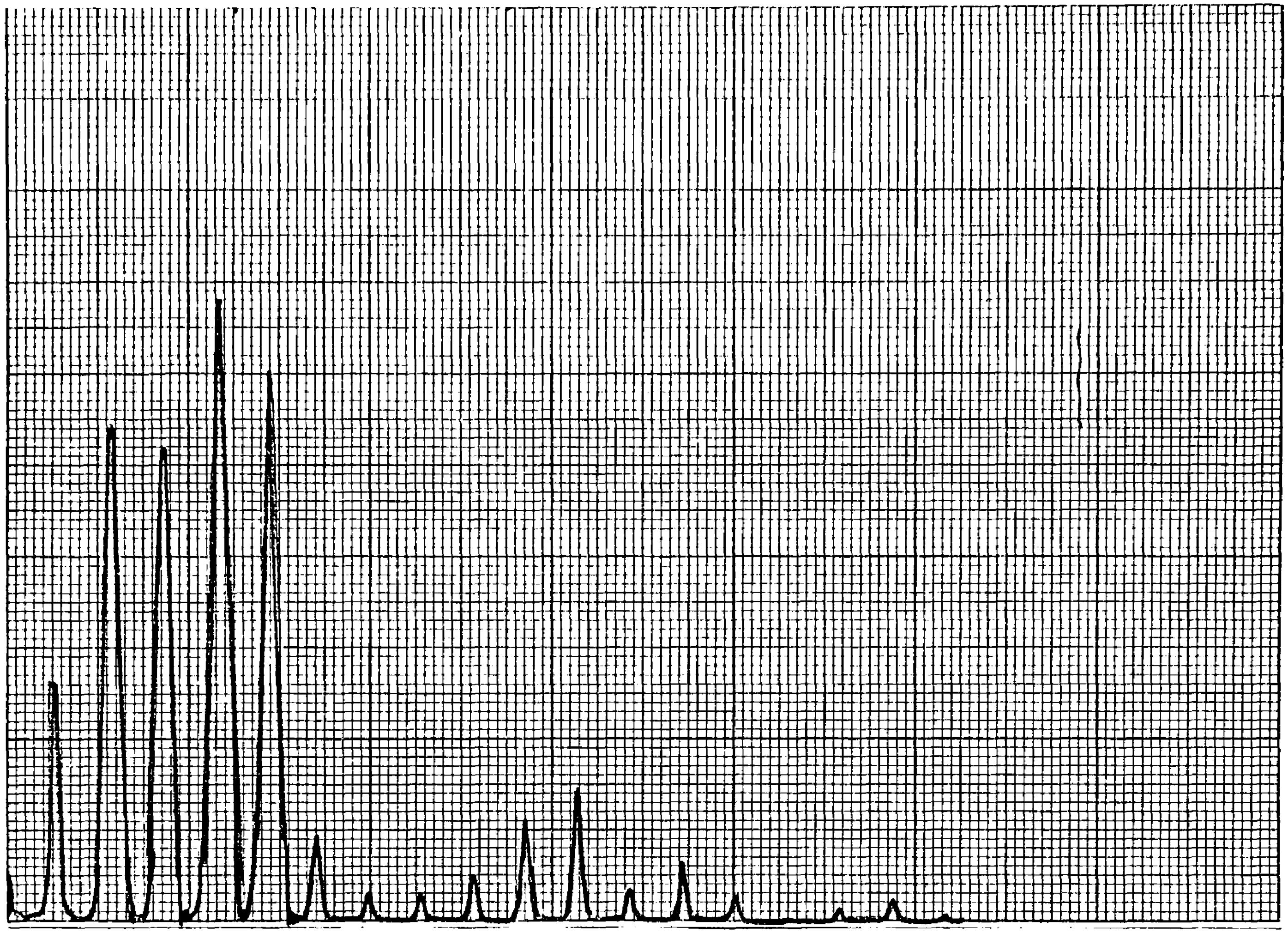
Spectrum Analysis Graph: Group IV, Subject Number 23, Pitch f.



Spectrum Analysis Graph: Group IV, Subject Number 23, Pitch b^b.



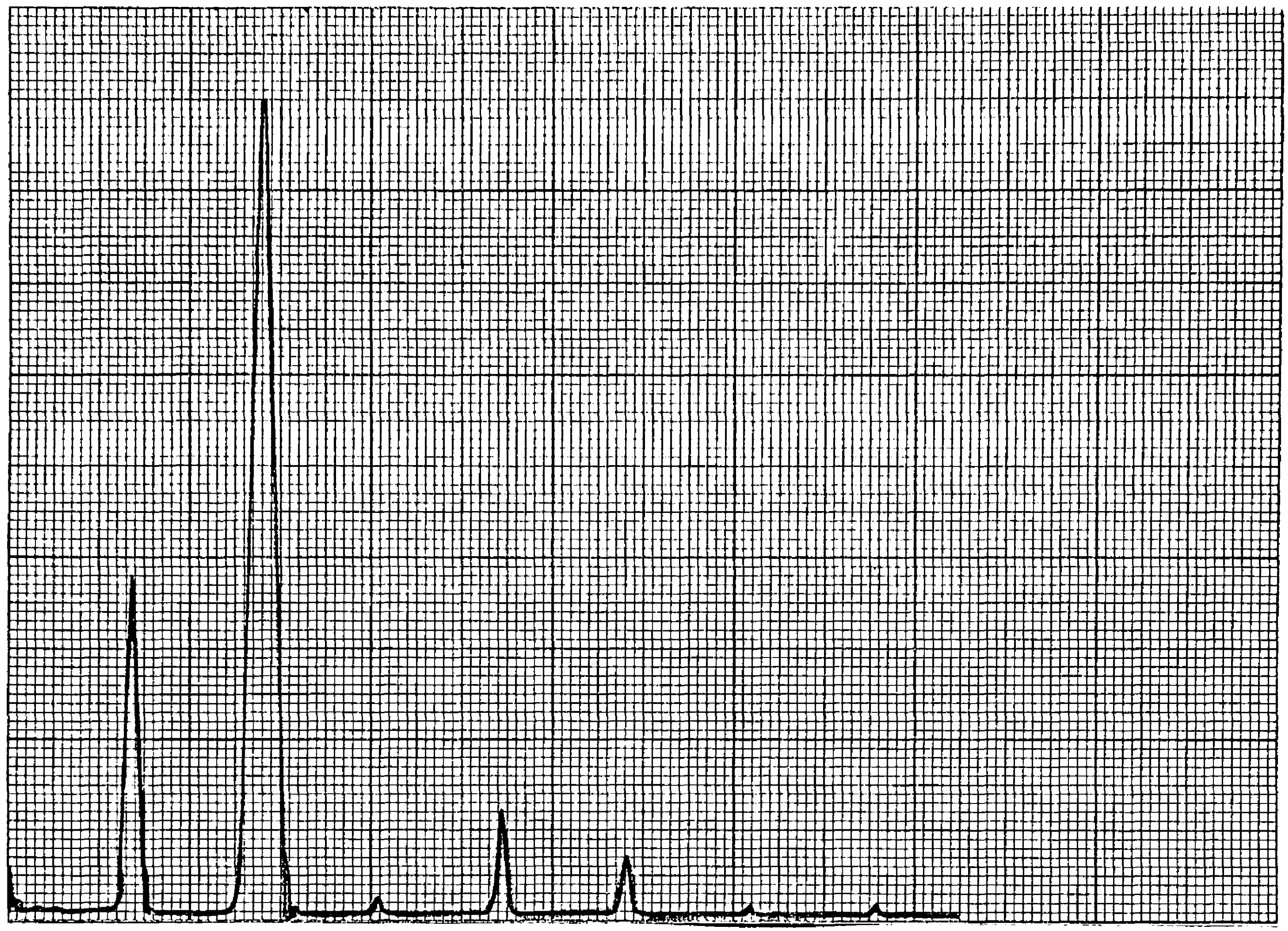
Spectrum Analysis Graph: Group IV, Subject Number 23, Pitch e^b.



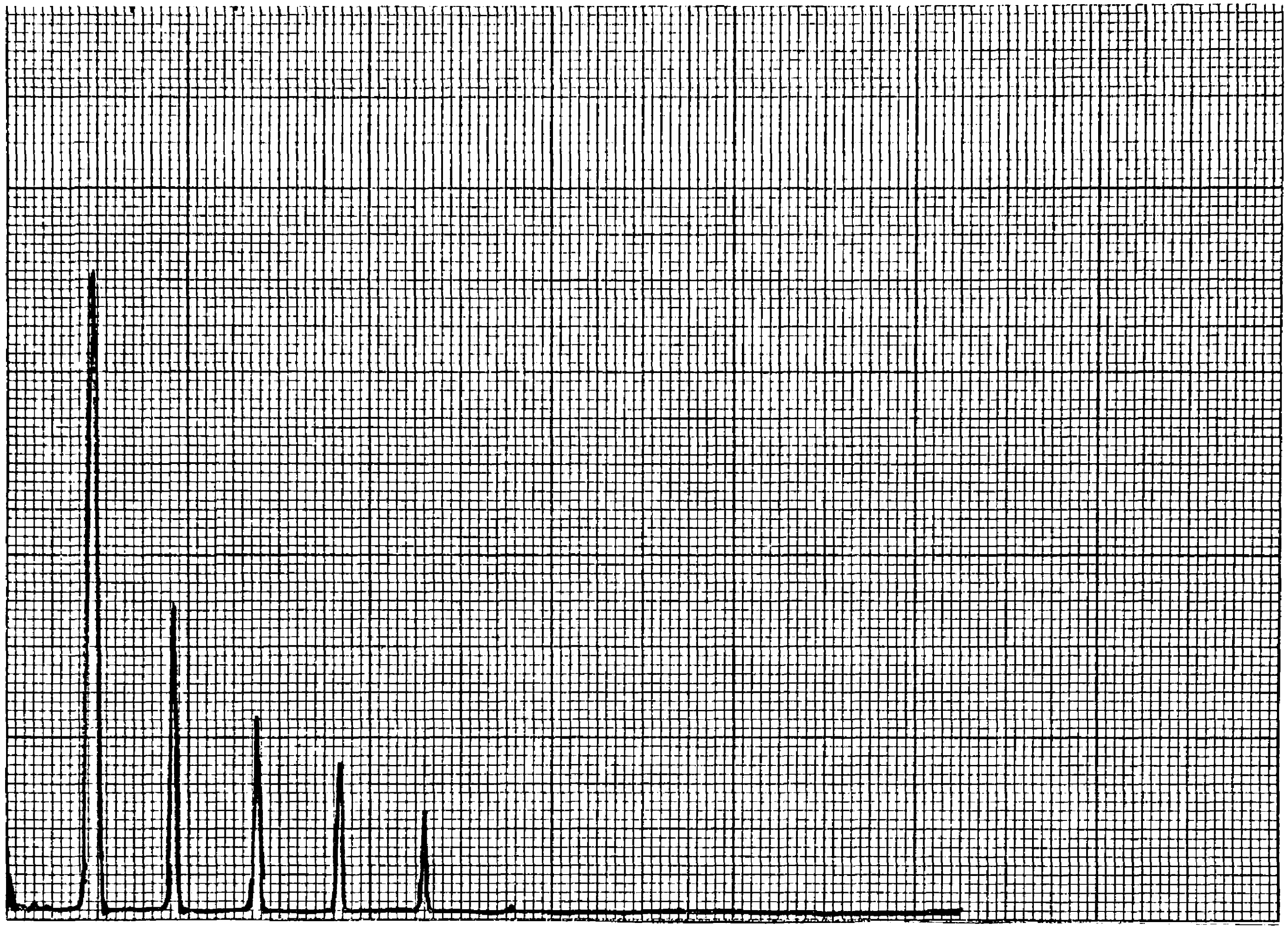
Spectrum Analysis Graph: Group IV, Subject Number 24, Pitch d.

Spectrum Analysis Graph: Group IV, Subject Number 24, Pitch g.

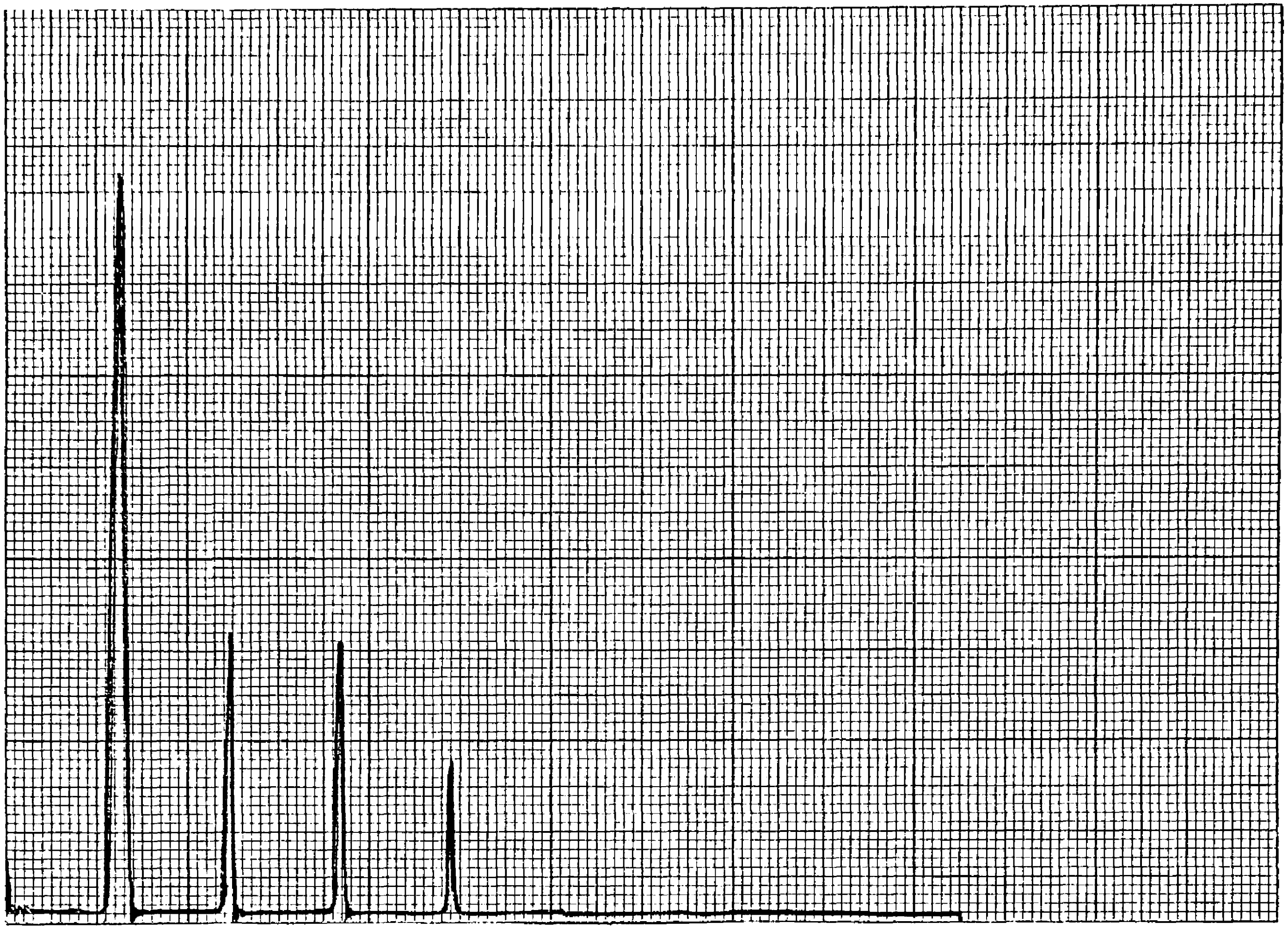
Spectrum Analysis Graph: Group IV, Subject Number 24, Pitch c.



Spectrum Analysis Graph: Group IV, Subject Number 24, Pitch f.



Spectrum Analysis Graph: Group IV, Subject Number 24, Pitch b^{b}.

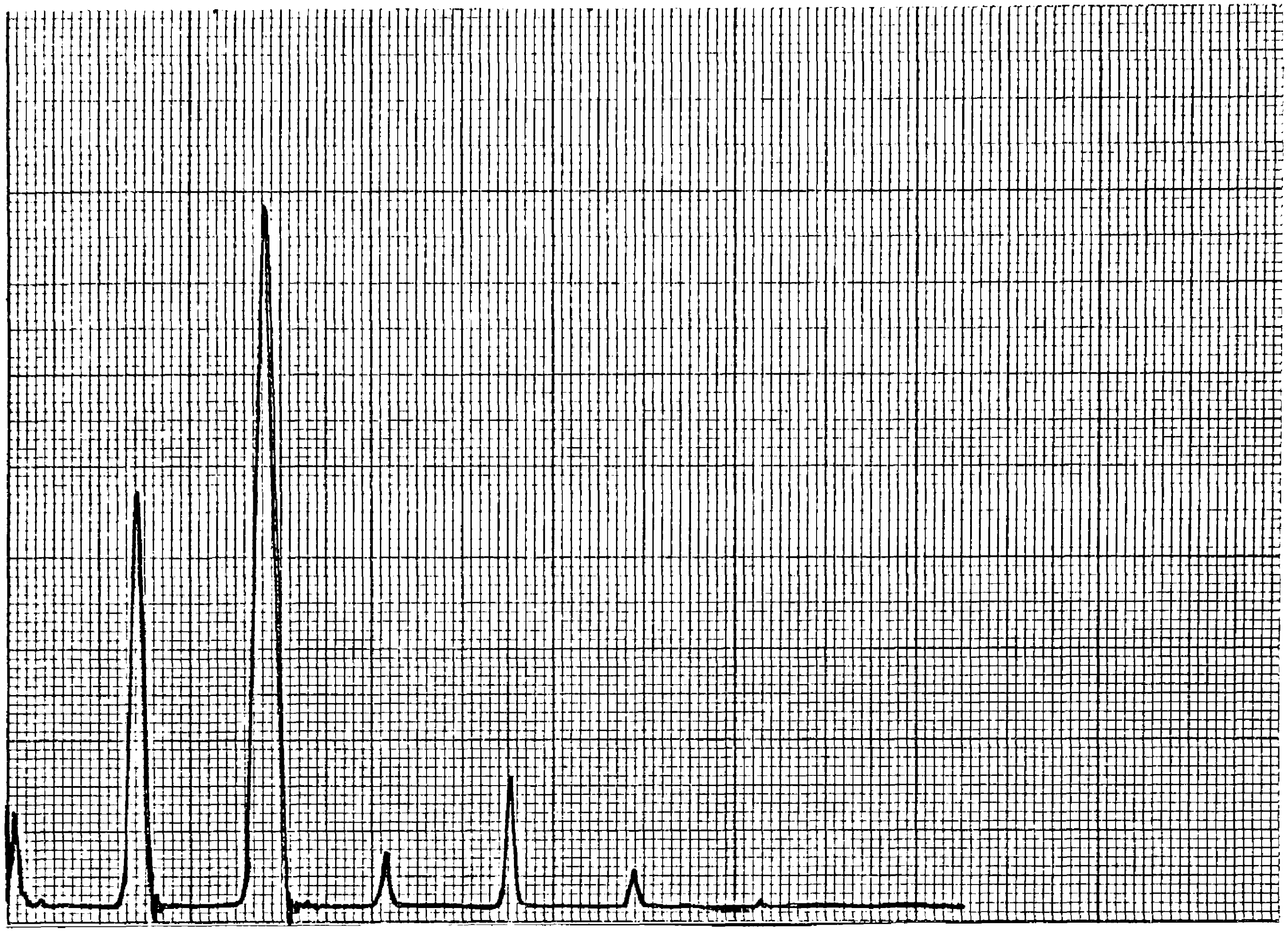


Spectrum Analysis Graph: Group IV, Subject Number 24, Pitch e^b.

Spectrum Analysis Graph: Group IV, Subject Number 34, Pitch d.

Spectrum Analysis Graph: Group IV, Subject Number 34, Pitch g.

Spectrum Analysis Graph: Group IV, Subject Number 34, Pitch c.



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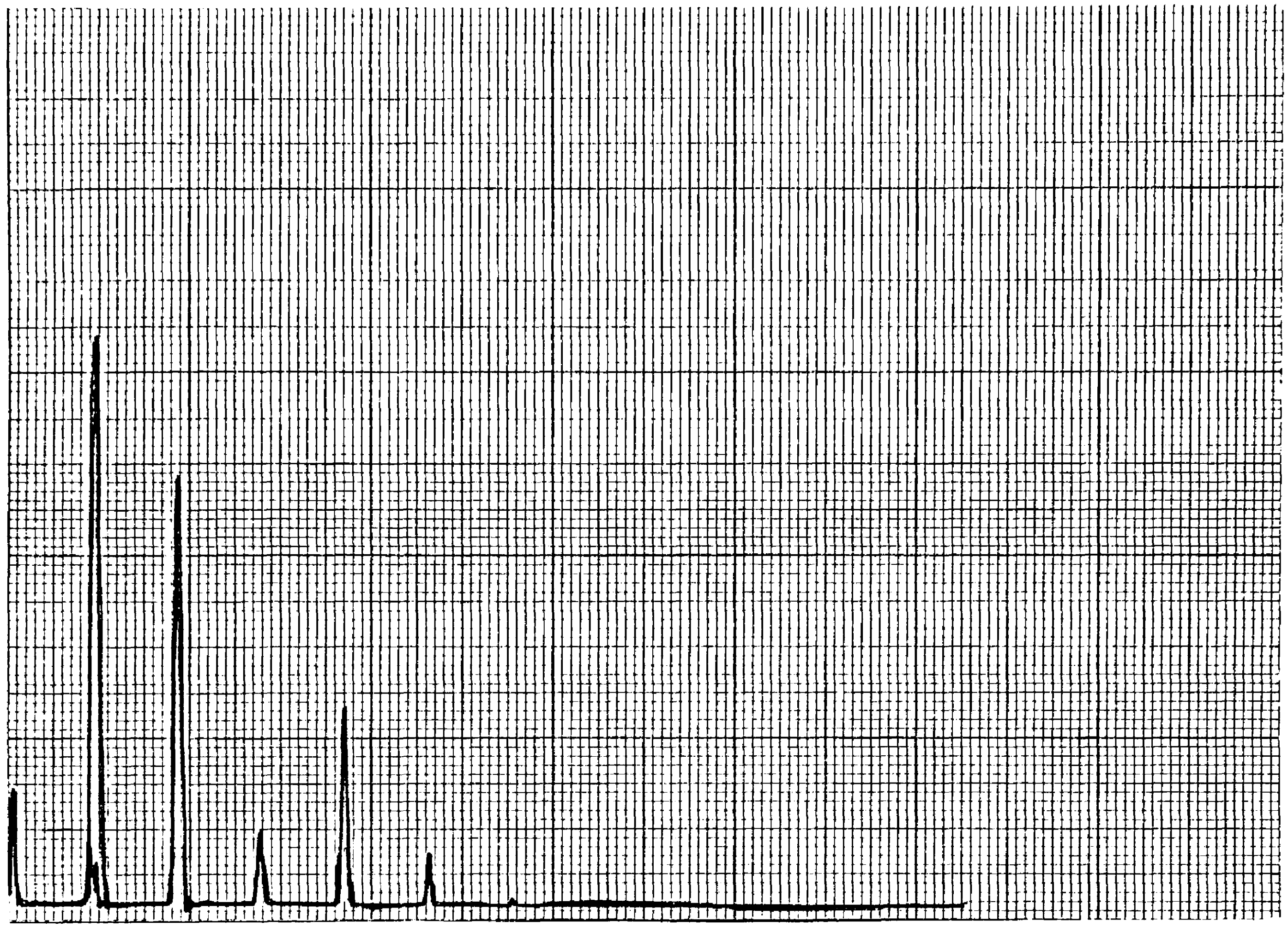
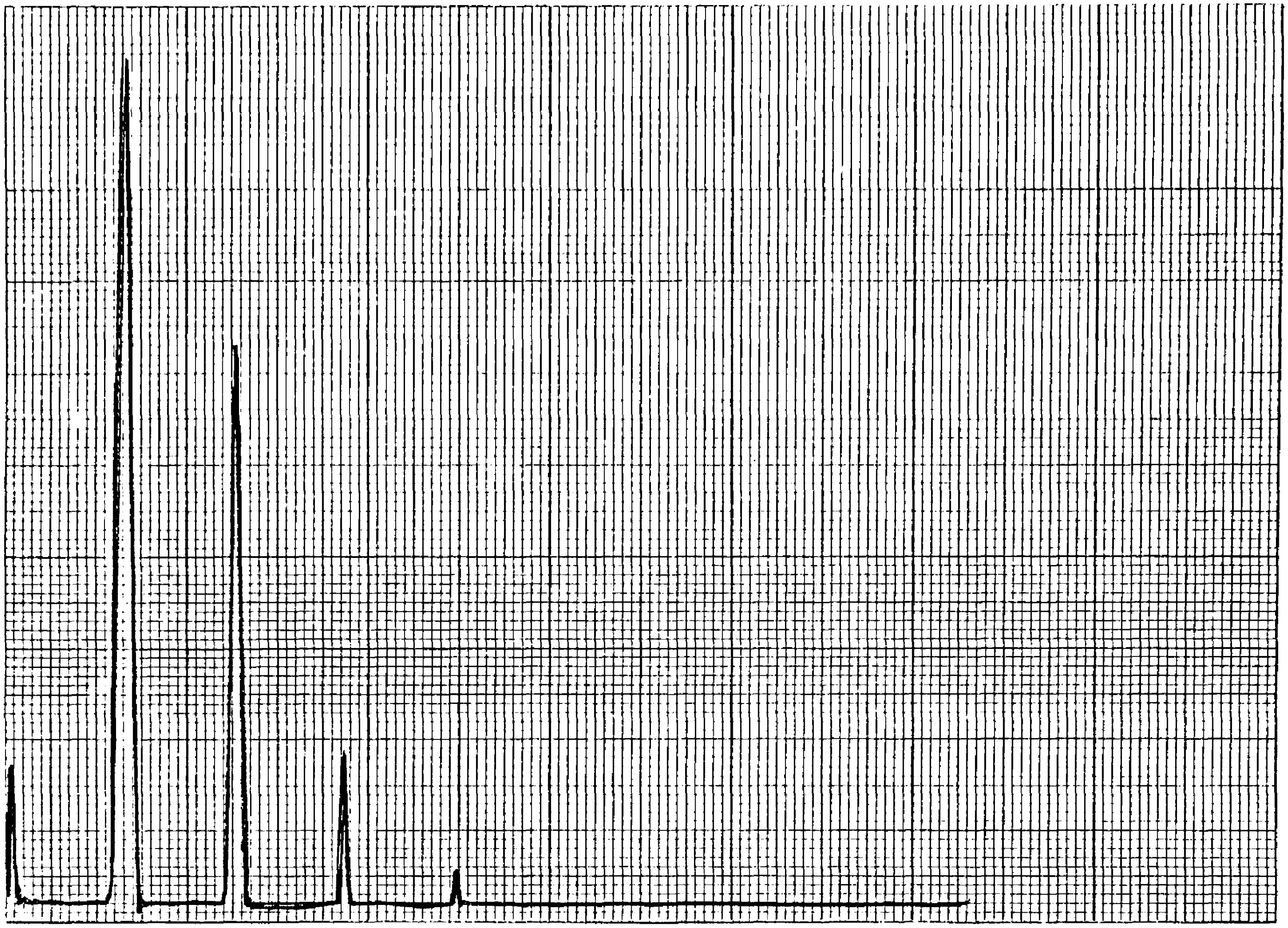
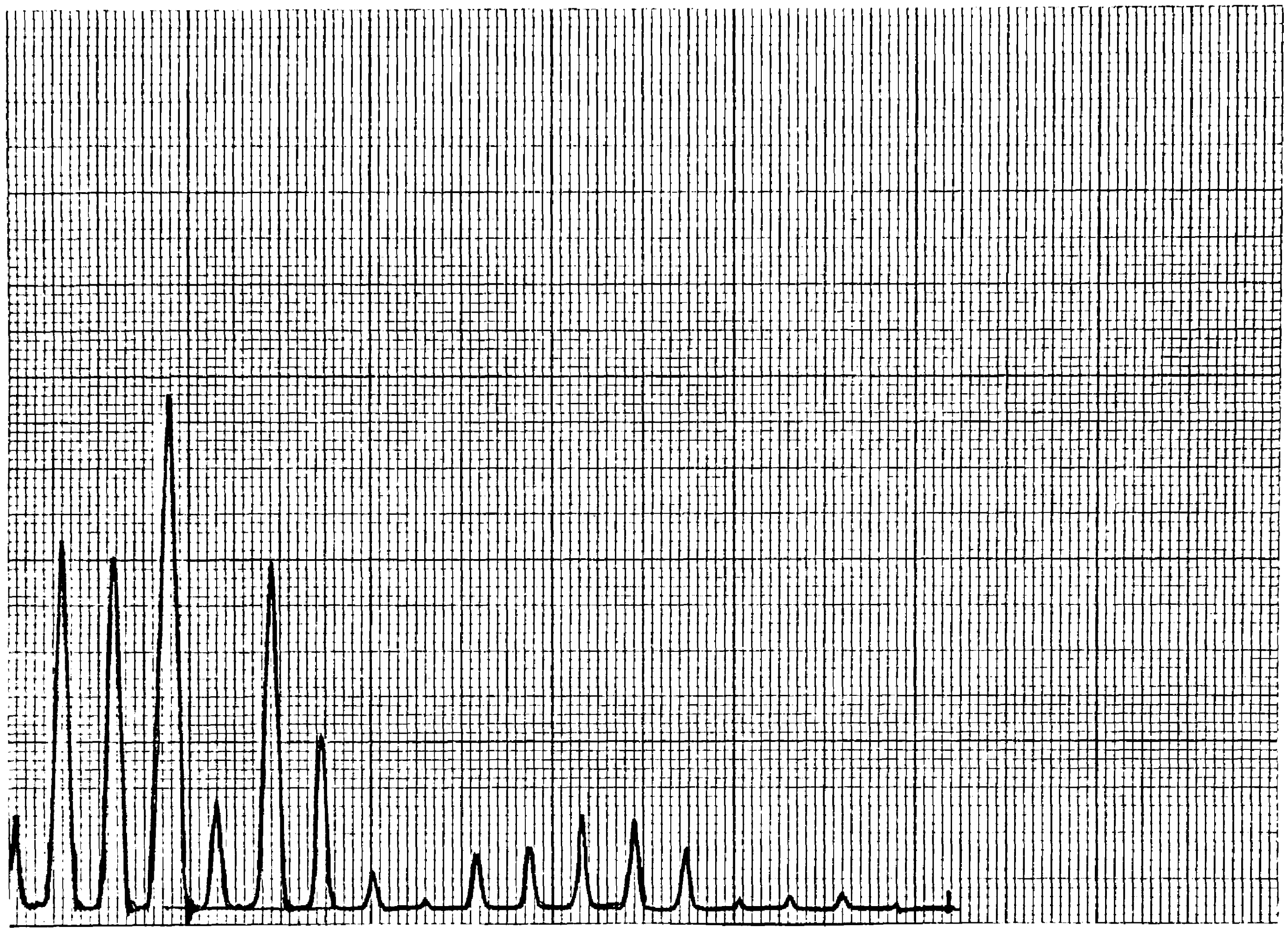


Spectrum Analysis Graph: Group IV, Subject Number 34, Pitch b^b.



Spectrum Analysis Graph: Group IV, Subject Number 34, Pitch e^b.

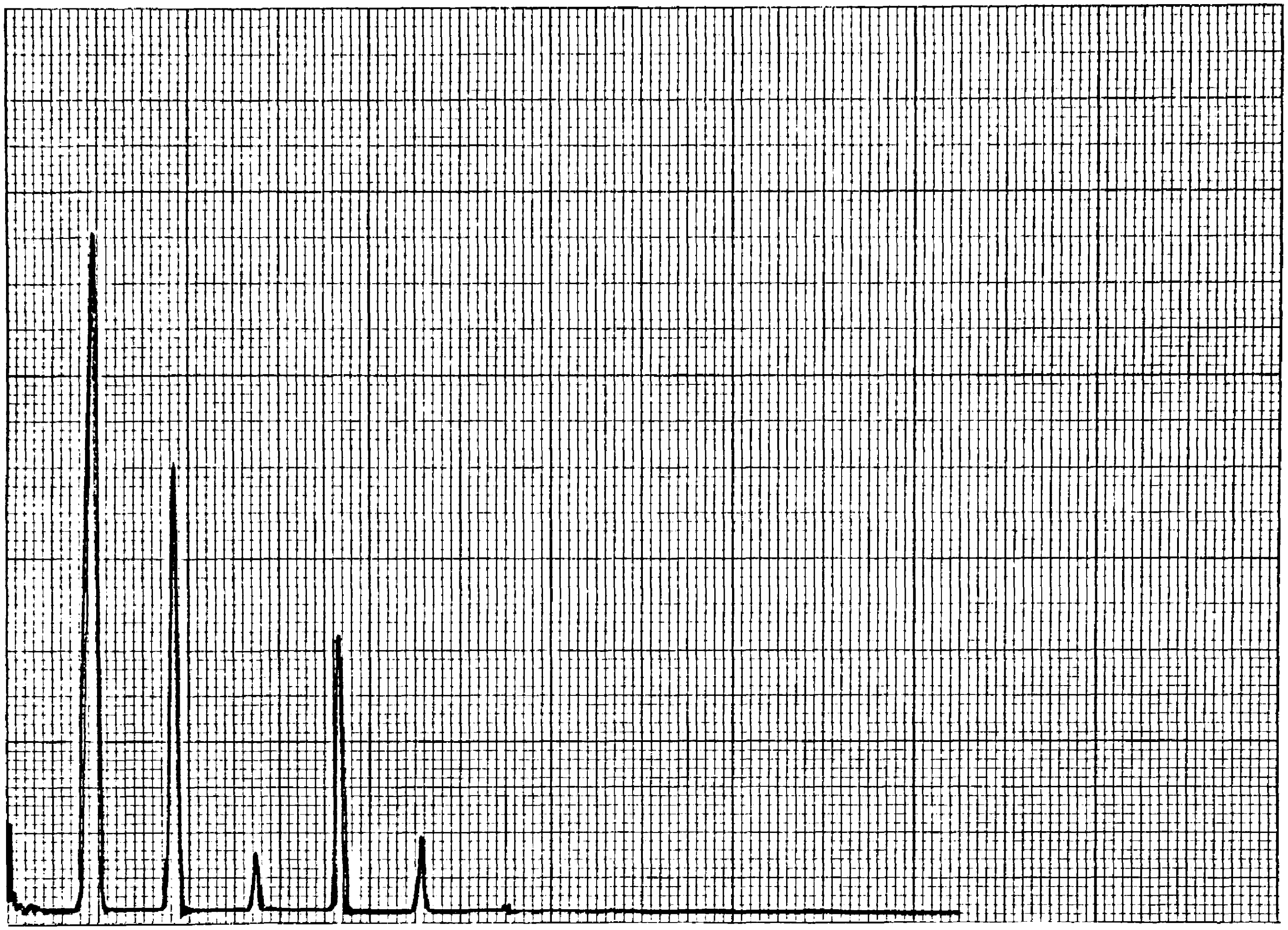


Spectrum Analysis Graph: Group IV, Subject Number 35, Pitch d.

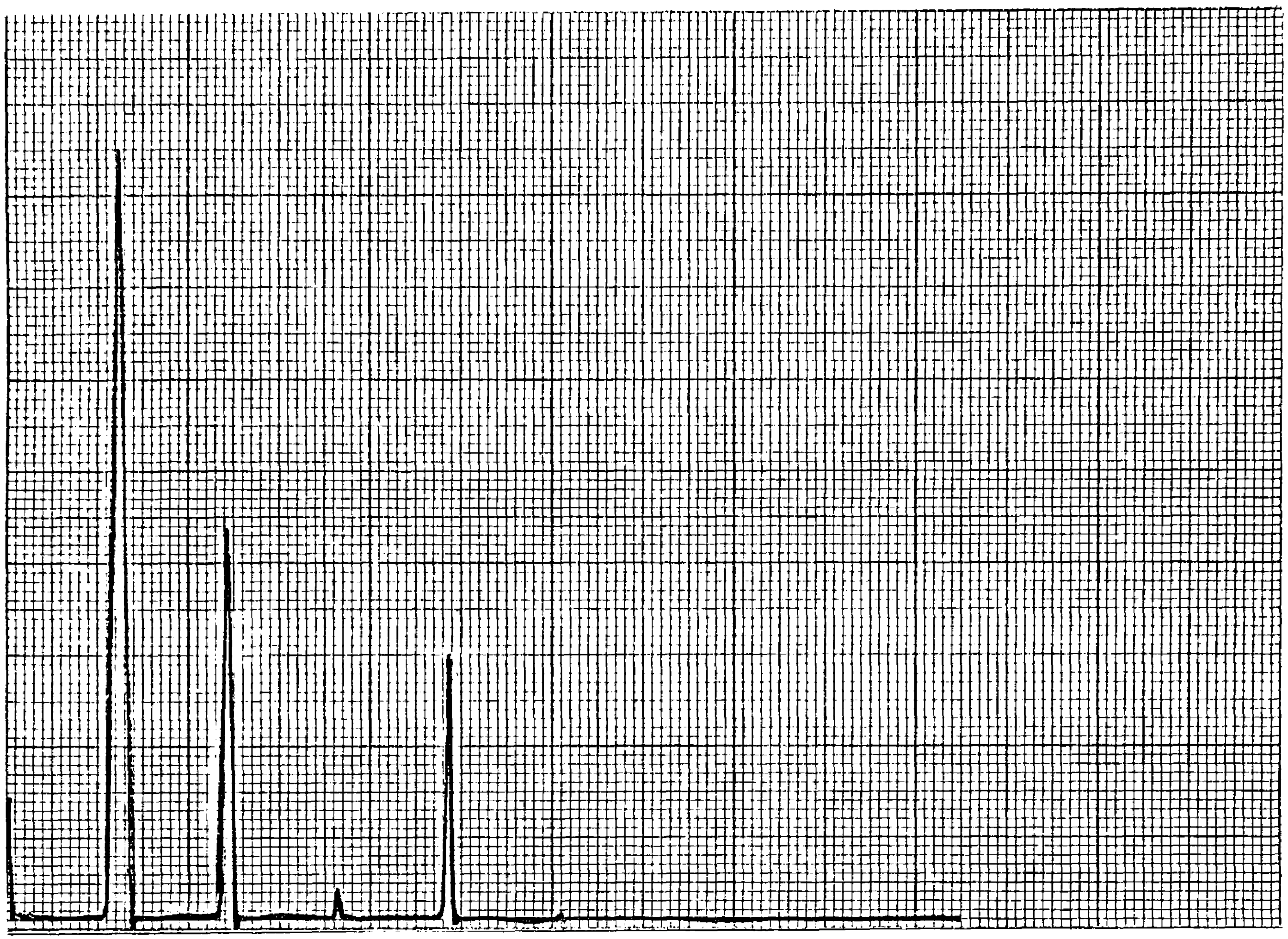
Spectrum Analysis Graph: Group IV, Subject Number 35, Pitch g.

Spectrum Analysis Graph: Group IV, Subject Number 35, Pitch c.

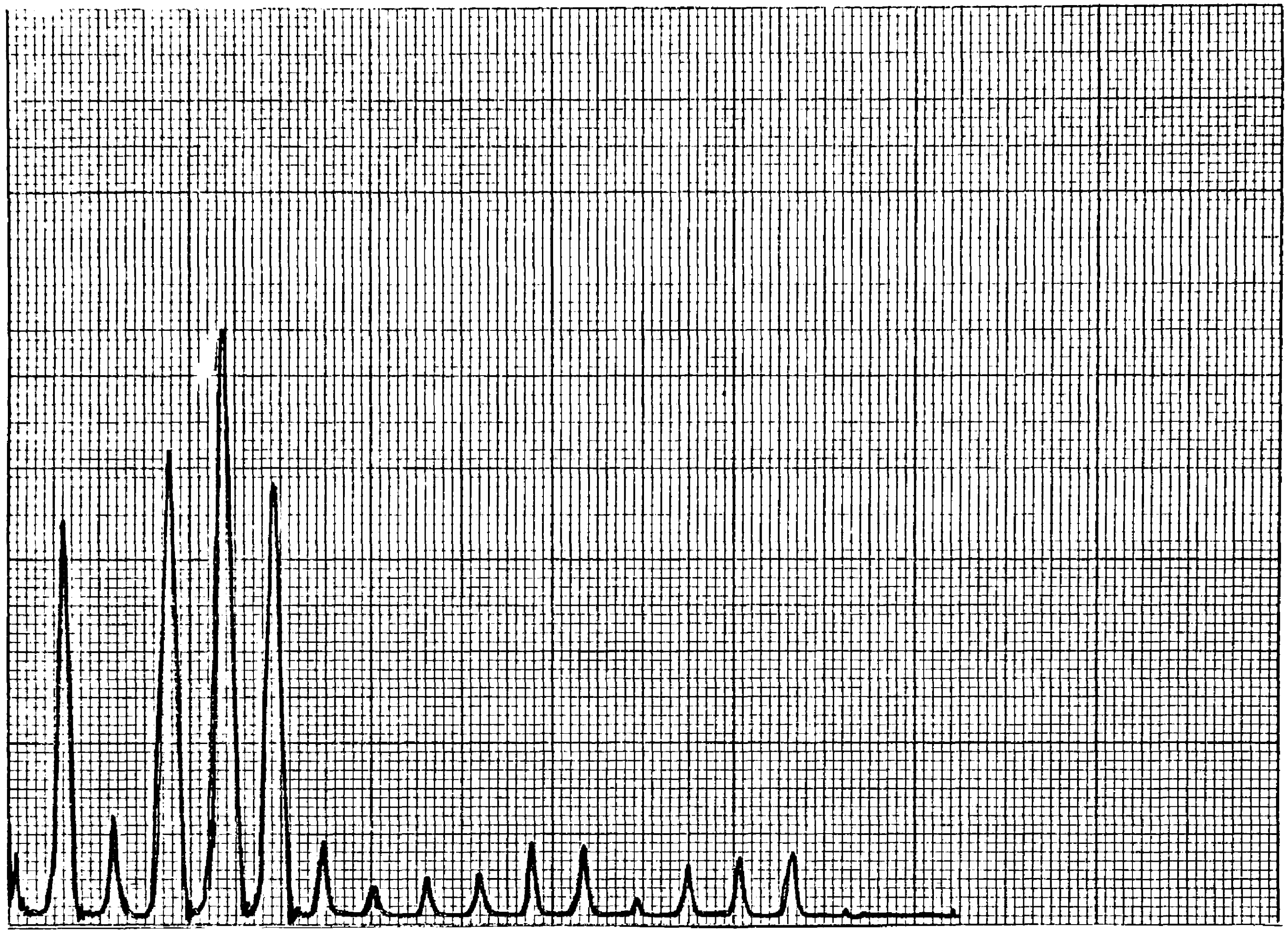
Spectrum Analysis Graph: Group IV, Subject Number 35, Pitch f.



Spectrum Analysis Graph: Group IV, Subject Number 35, Pitch b^b.



Spectrum Analysis Graph: Group IV, Subject Number 35, Pitch e^b.

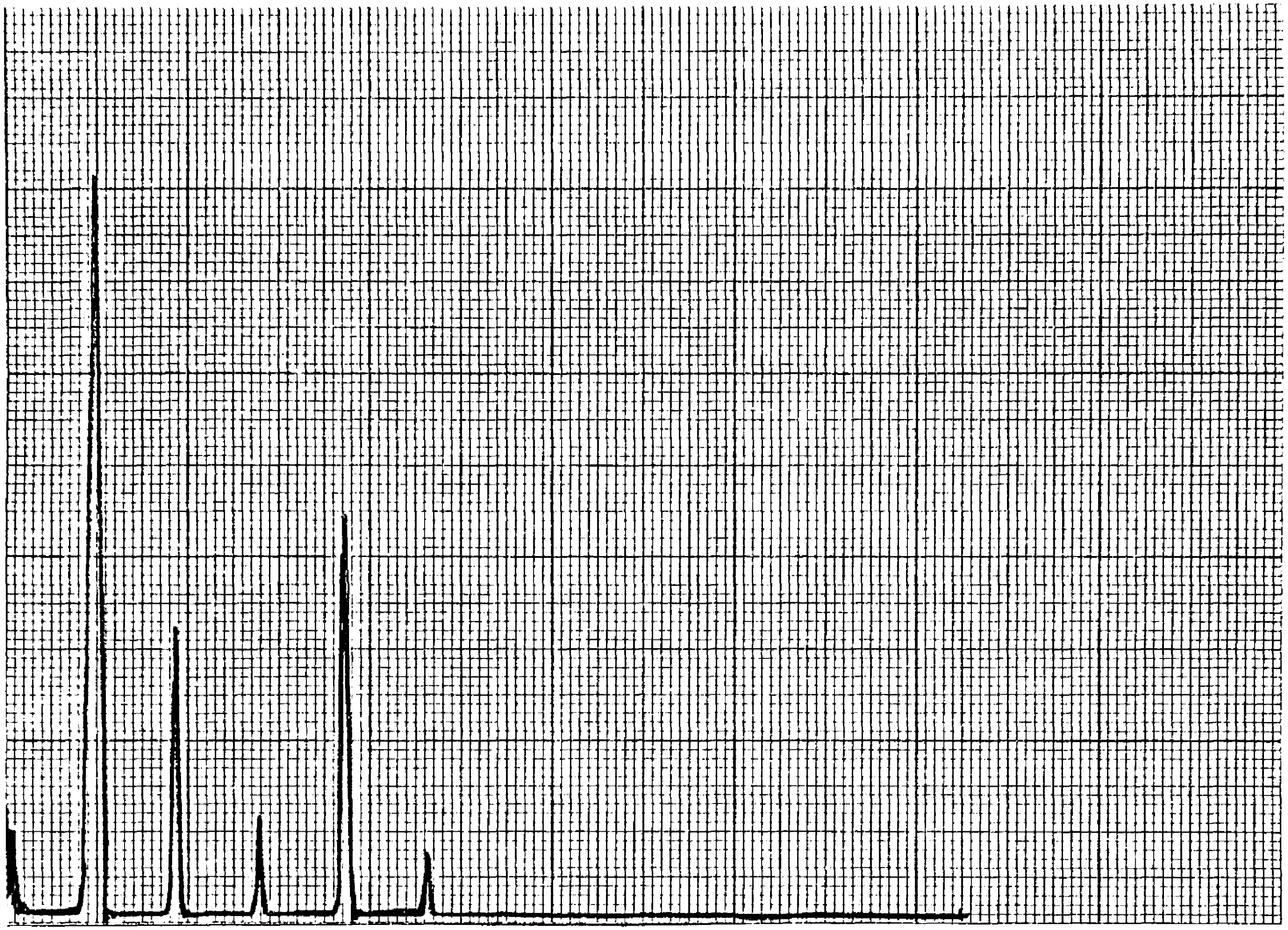


Spectrum Analysis Graph: Group IV, Subject Number 36, Pitch d.

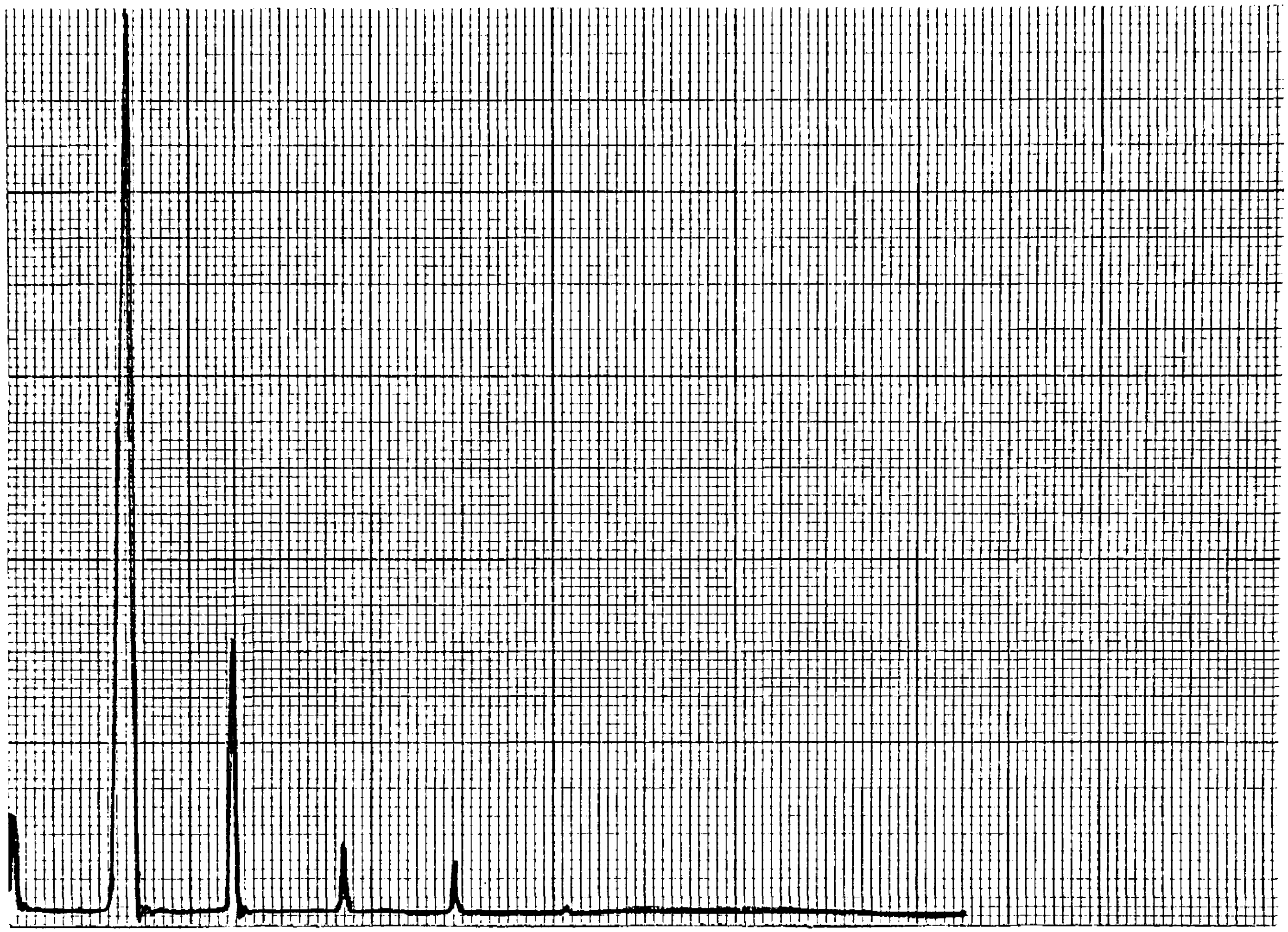
Spectrum Analysis Graph: Group IV, Subject Number 36, Pitch g.

Spectrum Analysis Graph: Group IV, Subject Number 36, Pitch c.

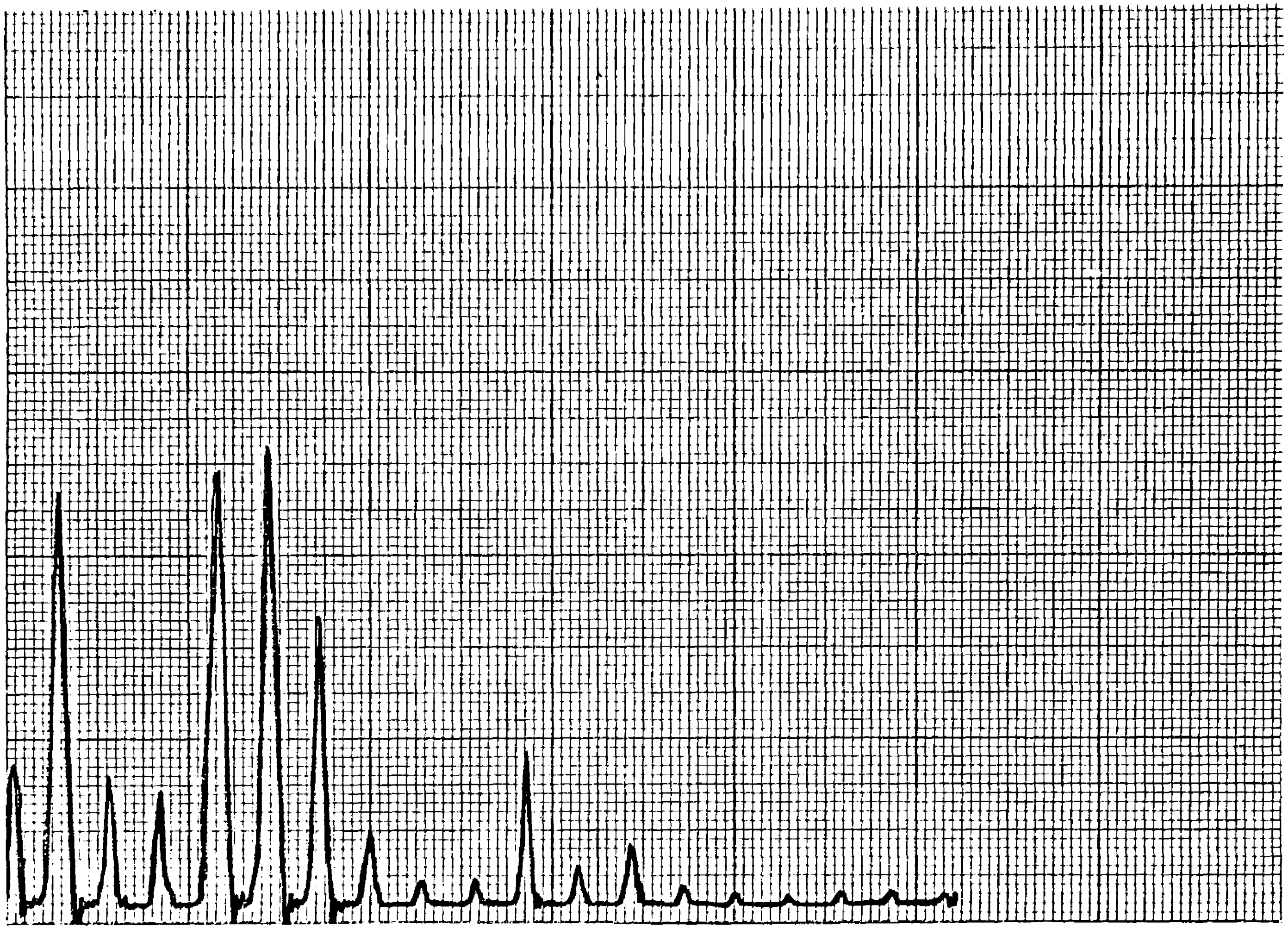
Spectrum Analysis Graph: Group IV, Subject Number 36, Pitch f.



Spectrum Analysis Graph: Group IV, Subject Number 36, Pitch b^b.

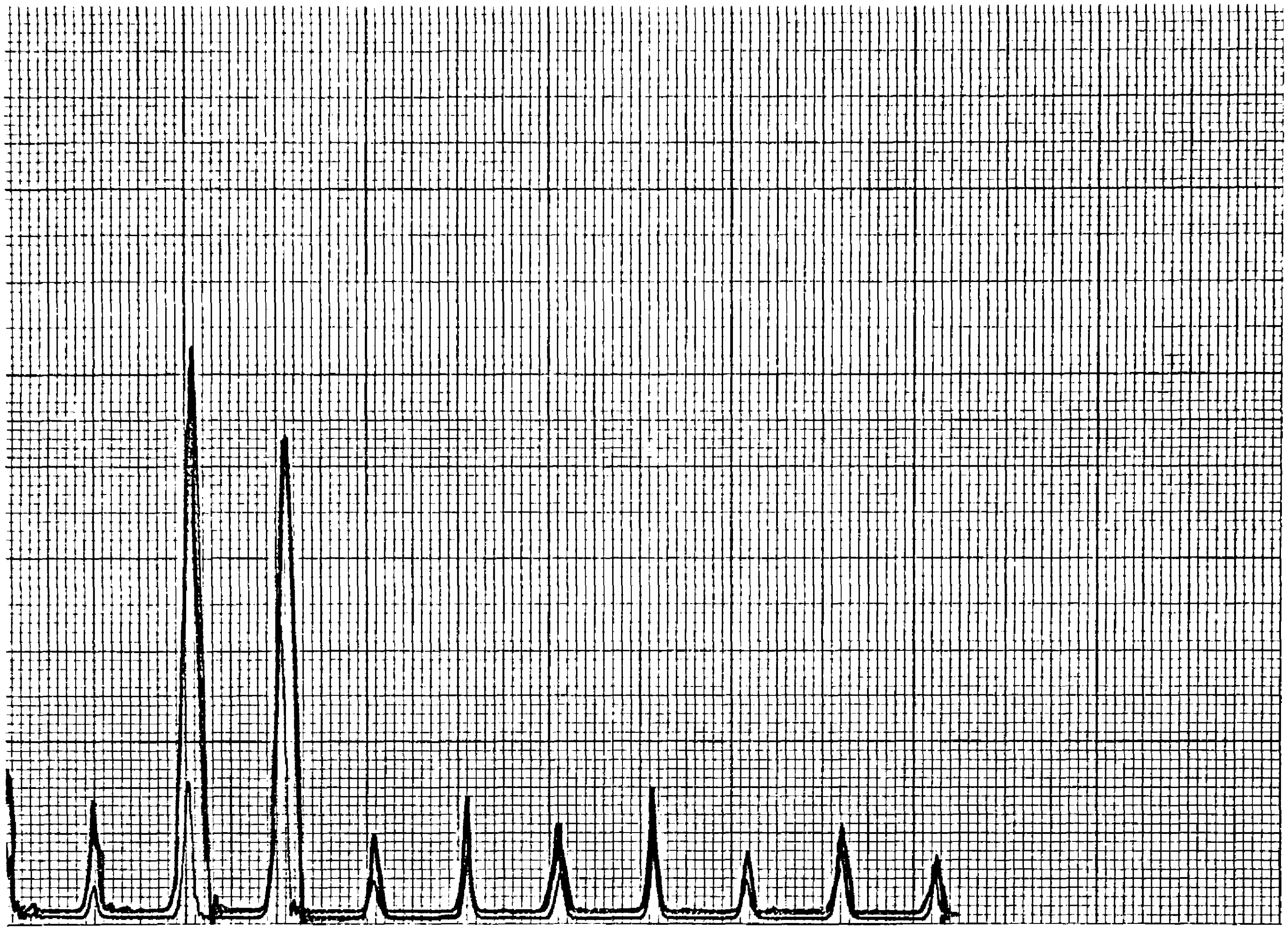


Spectrum Analysis Graph: Group IV, Subject Number 36, Pitch e^b.

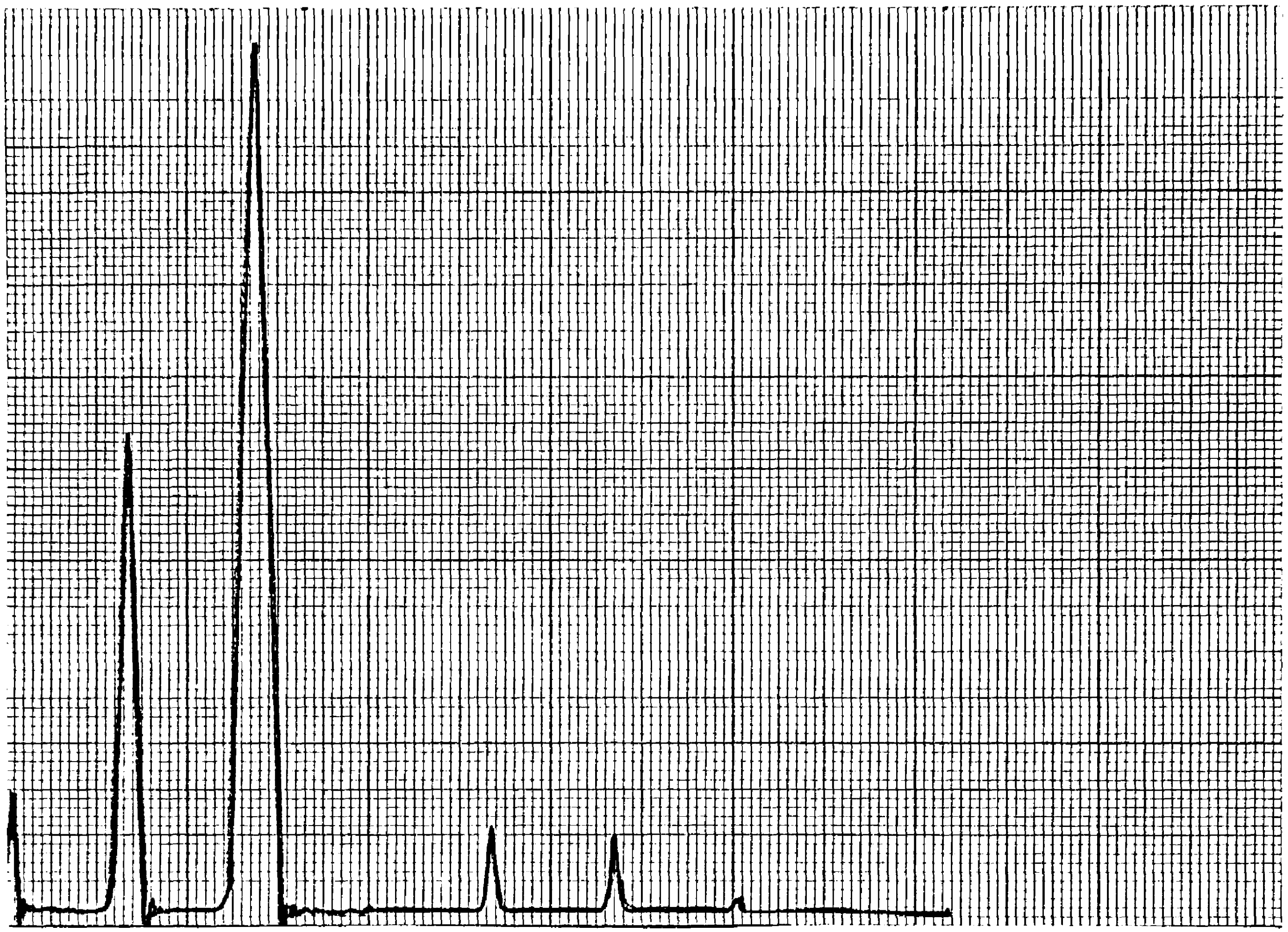


Spectrum Analysis Graph: Group IV, Subject Number 46, Pitch d.

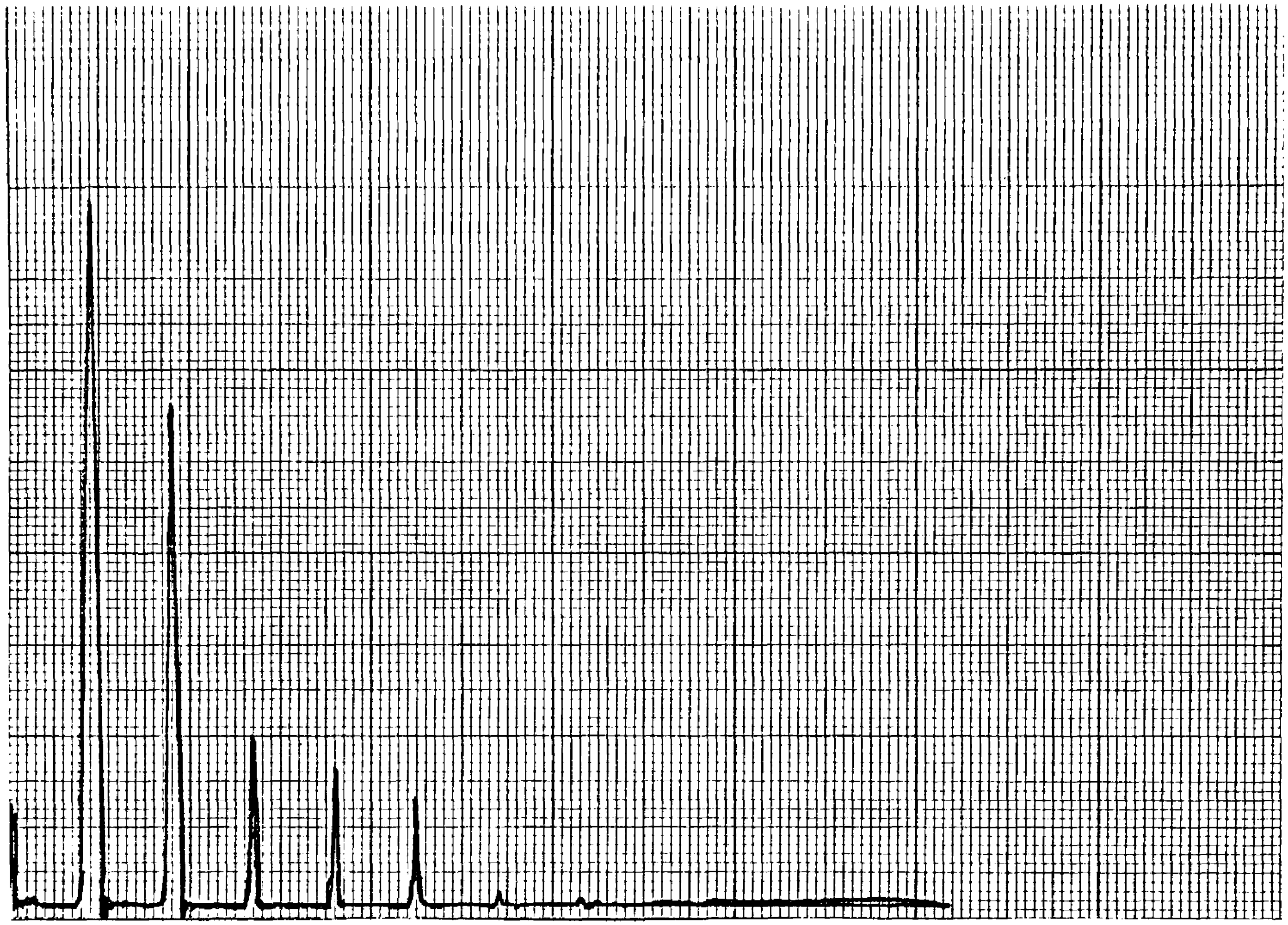
Spectrum Analysis Graph: Group IV, Subject Number 46, Pitch g.



Spectrum Analysis Graph: Group IV, Subject Number 46, Pitch c.



Spectrum Analysis Graph: Group IV, Subject Number 46, Pitch f.



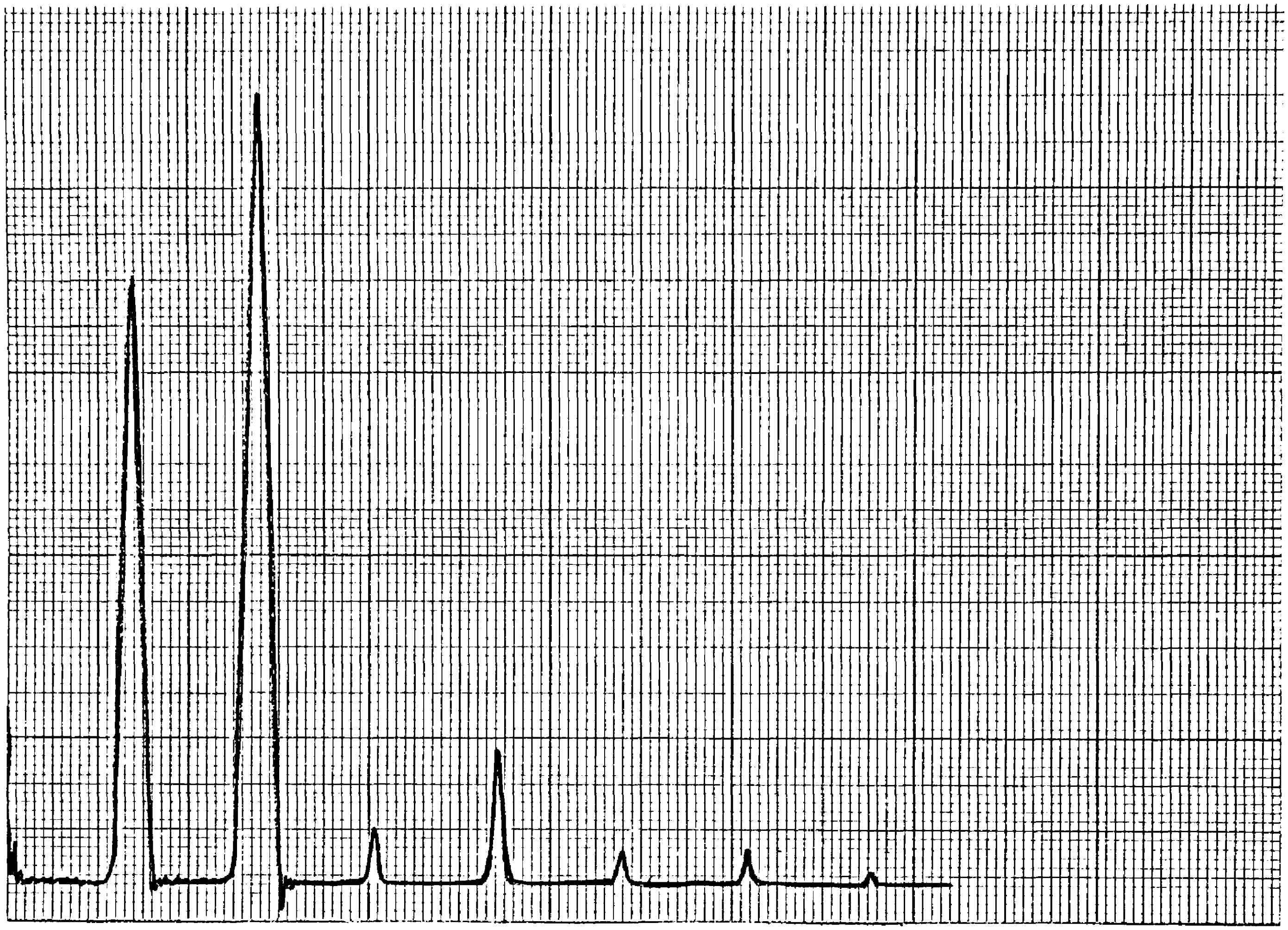
Spectrum Analysis Graph: Group IV, Subject Number 46, Pitch b^b.

Spectrum Analysis Graph: Group IV, Subject Number 46, Pitch e^{b}.

Spectrum Analysis Graph: Group IV, Subject Number 47, Pitch d.

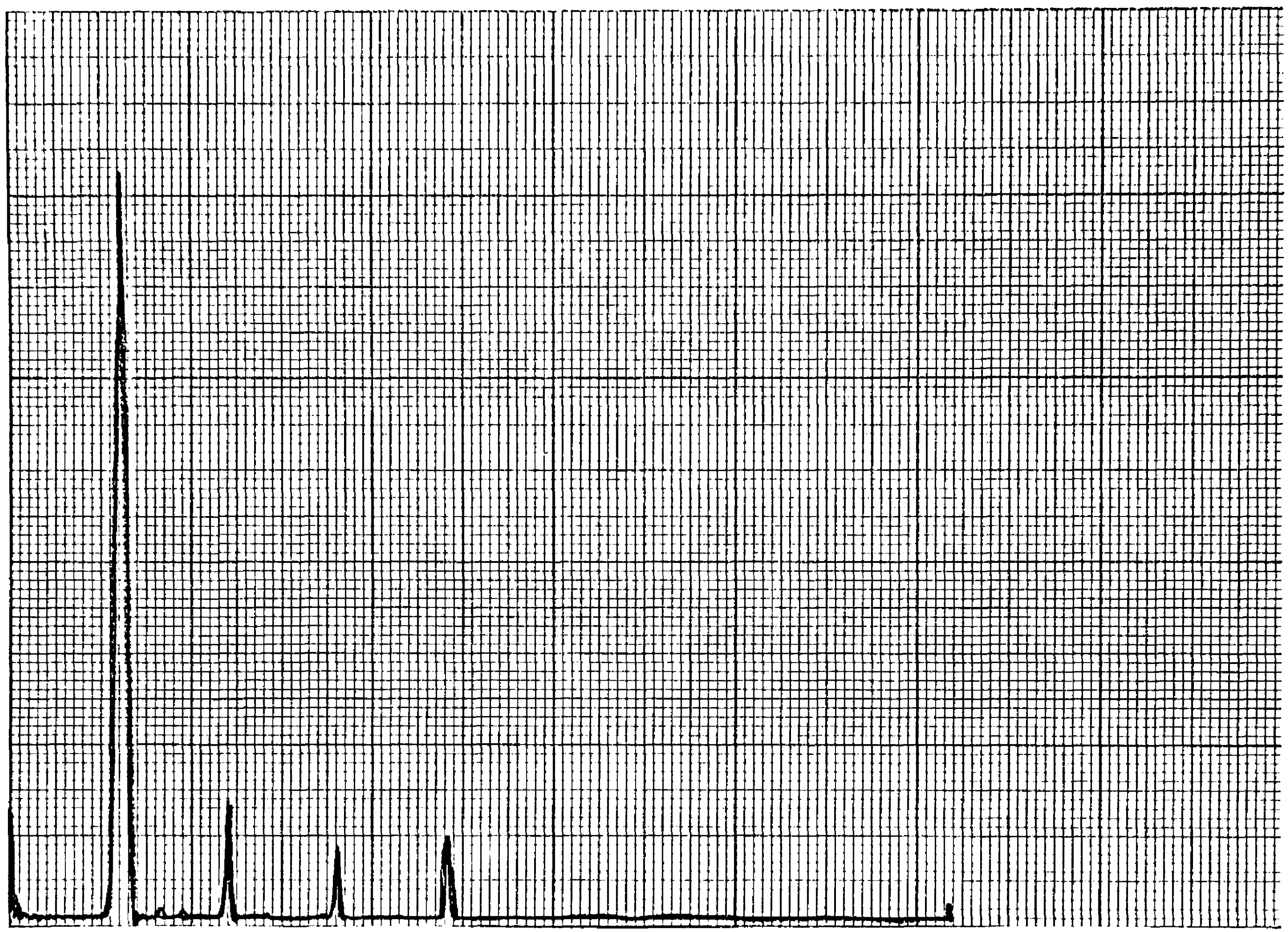
Spectrum Analysis Graph: Group IV, Subject Number 47, Pitch g.

Spectrum Analysis Graph: Group IV, Subject Number 47, Pitch c.



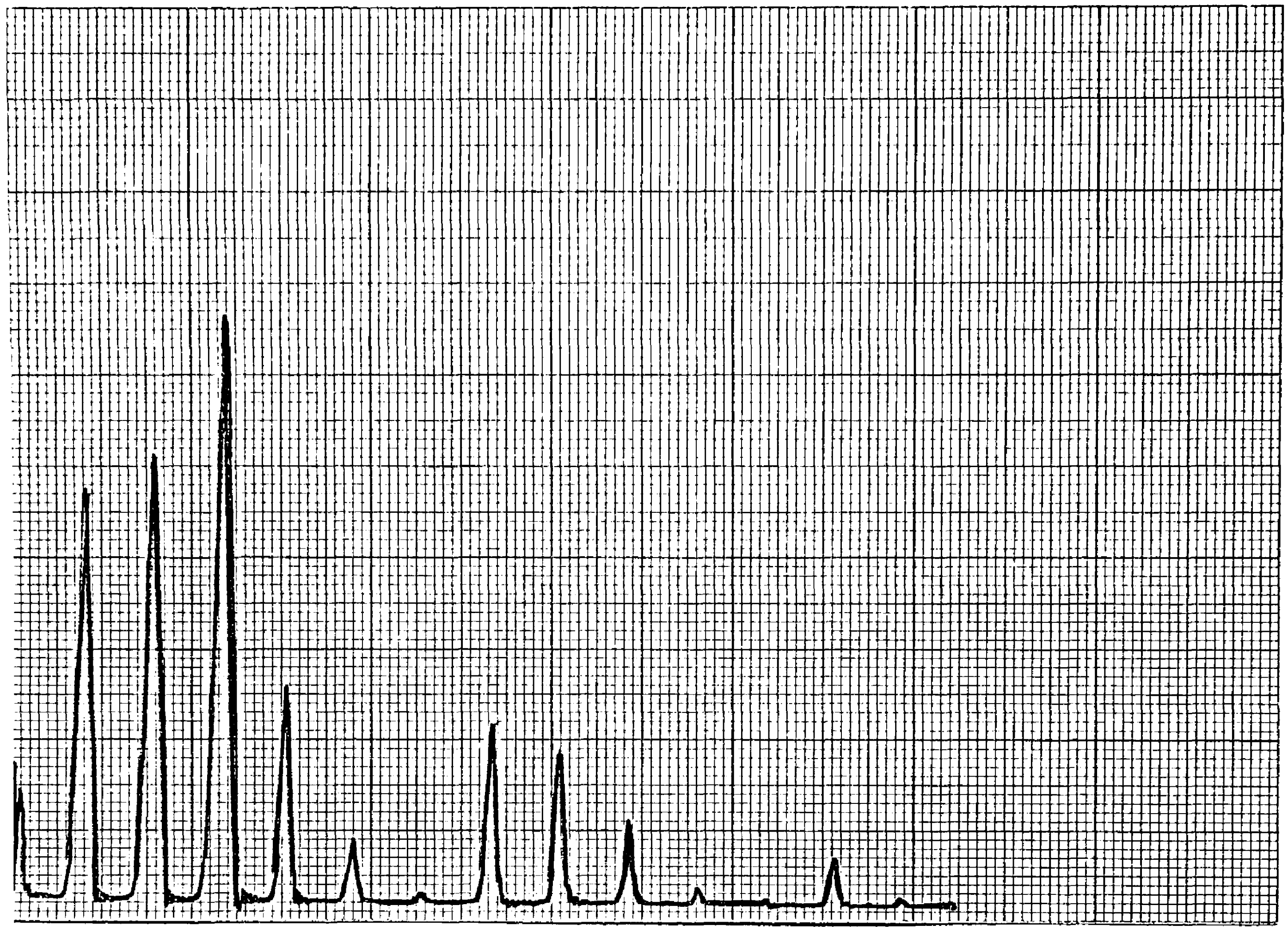
Spectrum Analysis Graph: Group IV, Subject Number 47, Pitch f.

Spectrum Analysis Graph: Group IV, Subject Number 47, Pitch b^b.

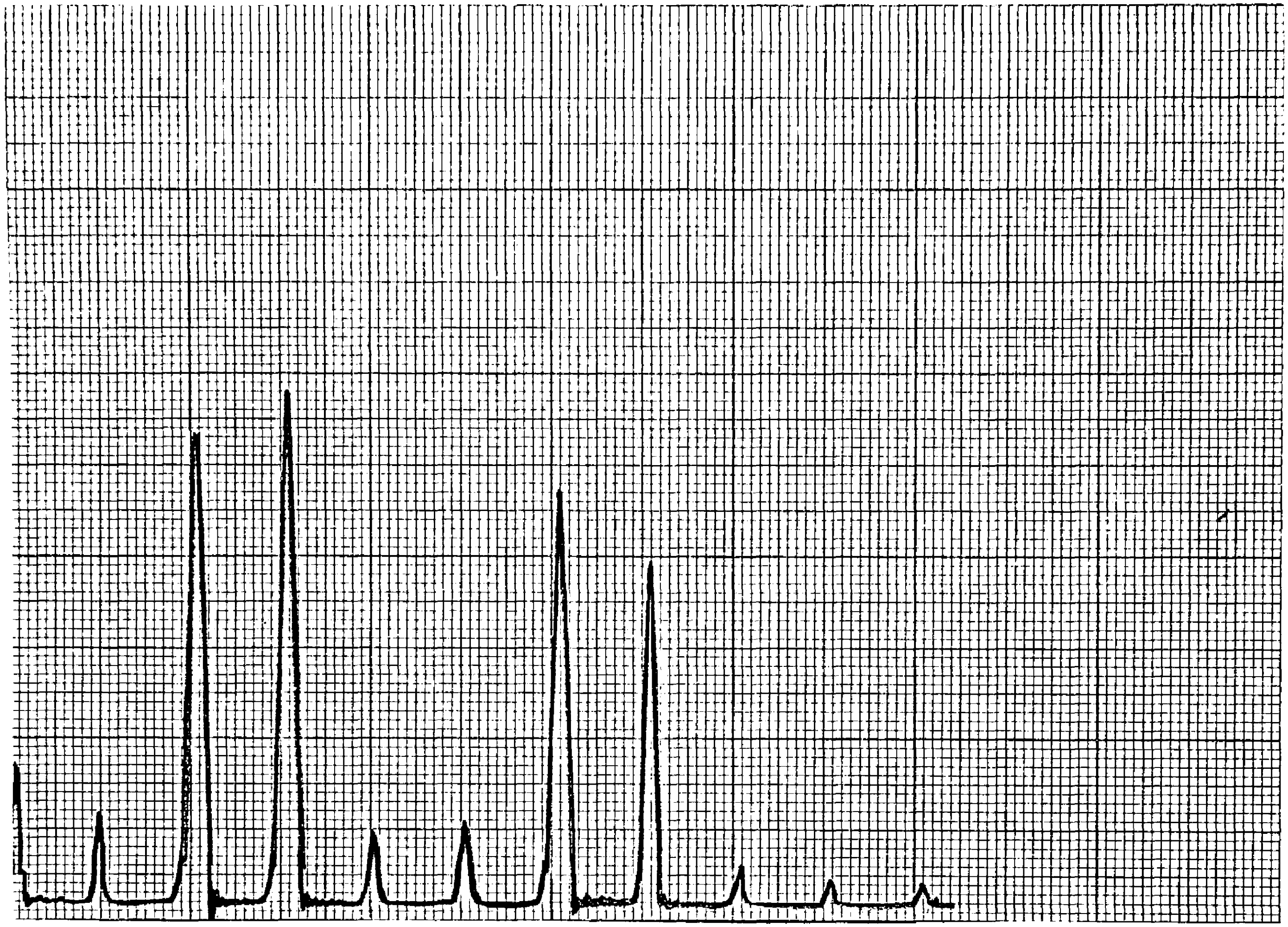


Spectrum Analysis Graph: Group IV, Subject Number 47, Pitch e^b.

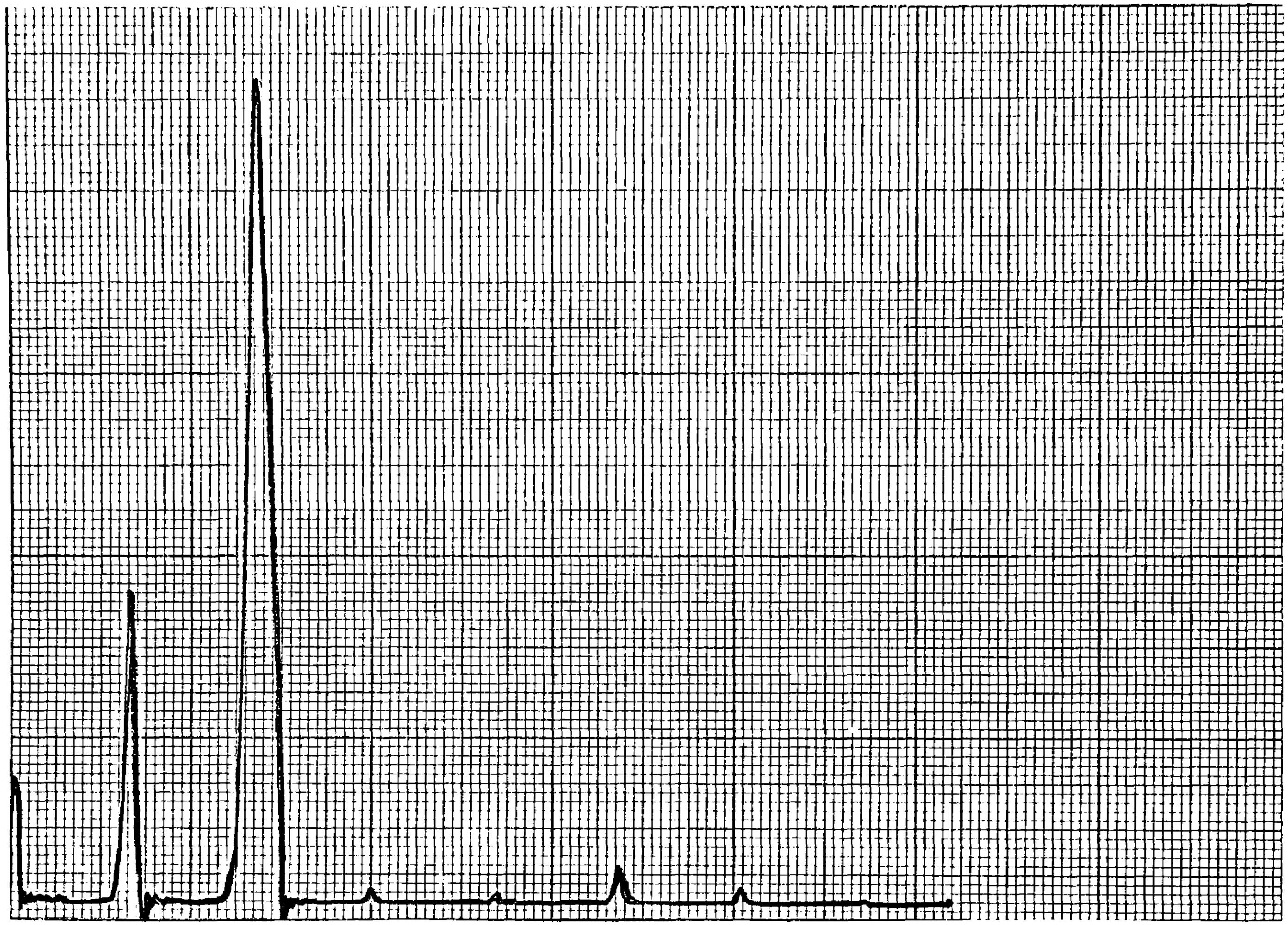
Spectrum Analysis Graph: Group IV, Subject Number 48, Pitch d.



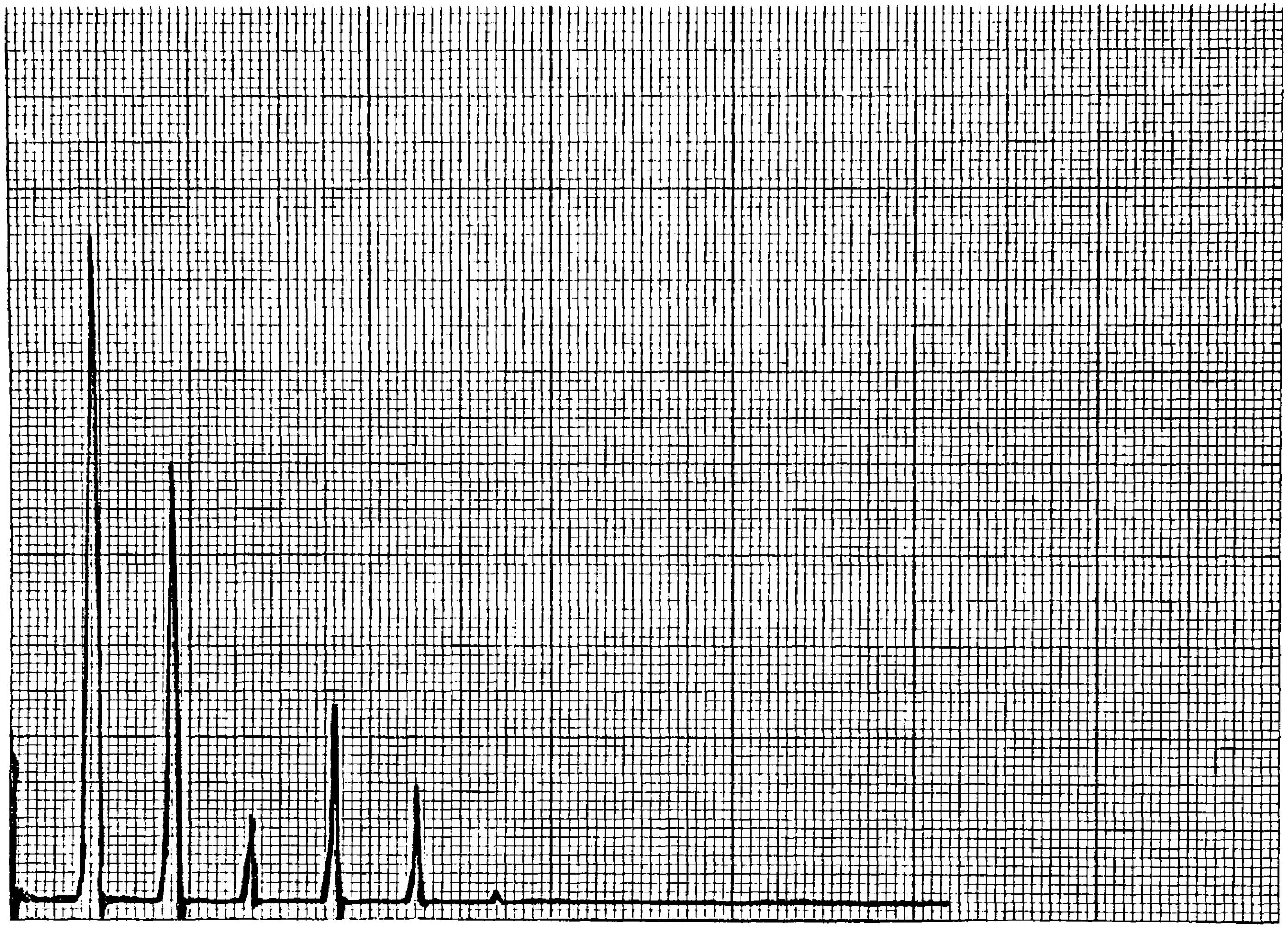
Spectrum Analysis Graph: Group IV, Subject Number 48, Pitch g.



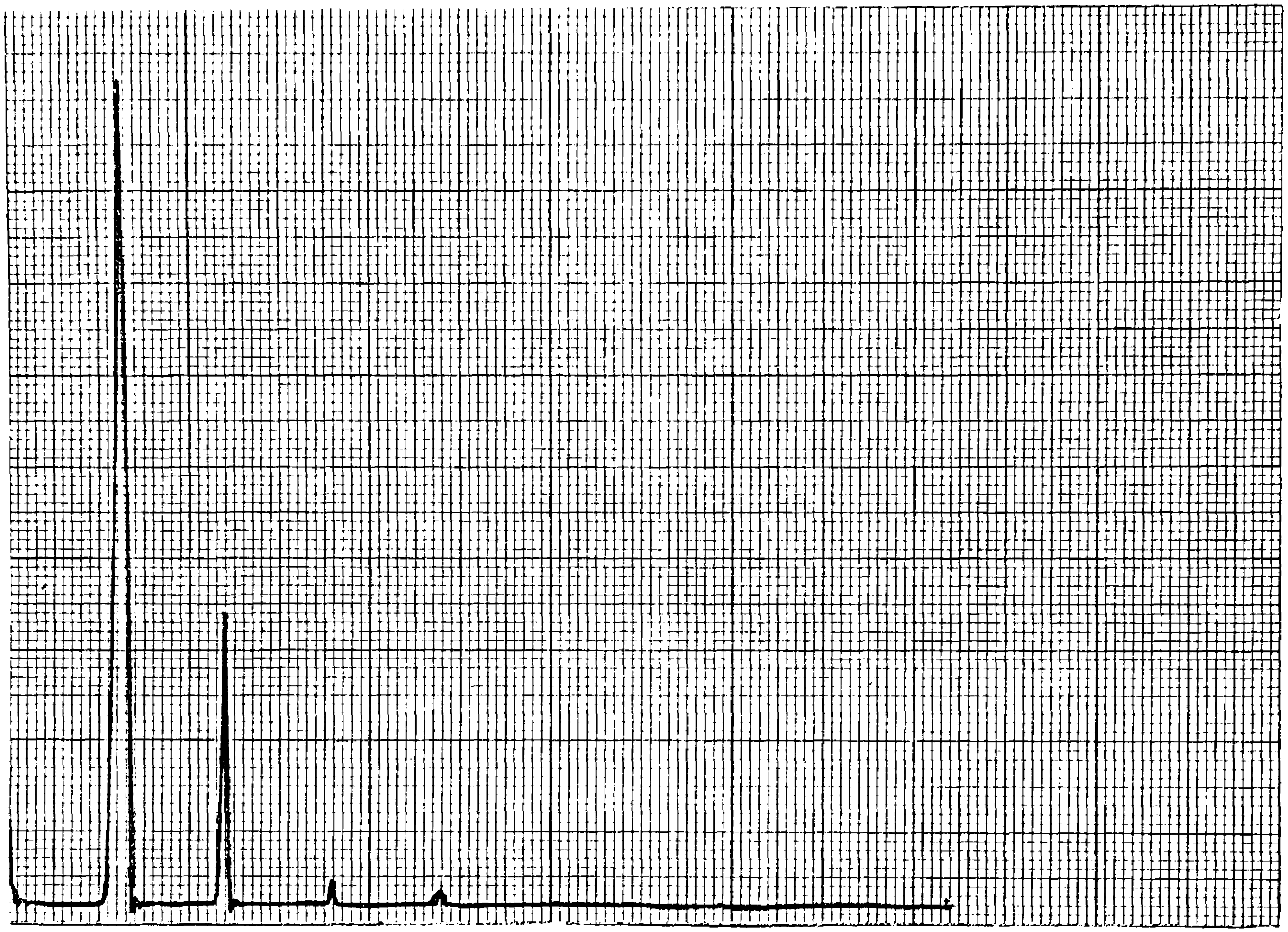
Spectrum Analysis Graph: Group IV, Subject Number 48, Pitch c.



Spectrum Analysis Graph: Group IV, Subject Number 48, Pitch f.



Spectrum Analysis Graph: Group IV, Subject Number 48, Pitch b^b.



Spectrum Analysis Graph: Group IV, Subject Number 48, Pitch e^{b}.

APPENDIX B

COMPUTER ANALYSIS

```
NOTE. THE JOB OSTOICH HAS BEEN RUN UNDER RELEASE 79 3A OF SAS AT NORTHEAST REGIONAL DATA CENTER

1          DATA;
2          INPUT GROUP 1 PITCH1 4 @5 (O1T1-O1T18)(18*3.) #2 PITCH2 4 @5 (O2T1-O2T18)(18*3.)
3            #3 PITCH3 4 @5 (O3T1-O3T18)(18*3.) #4 PITCH4 4 @5 (O4T1-O4T18)(18*3.)
4            #5 PITCH5 4 @5 (O5T1-O5T18)(18*3.) #6 PITCH6 4 @5 (O6T1-O6T18)(18*3.);
5          CARDS;

NOTE. DATA SET WORK.DATA1 HAS 48 OBSERVATIONS AND 115 VARIABLES. 20 OBS/TRK.
NOTE. THE DATA STATEMENT USED 0.41 SECONDS AND 140K.

294        PROC SORT; BY GROUP;

NOTE: DATA SET WORK.DATA1 HAS 48 OBSERVATIONS AND 115 VARIABLES. 20 OBS/TRK.
NOTE: THE PROCEDURE SORT USED 0.38 SECONDS AND 248K.

295        PROC MEANS N NMISS MEAN STD MIN MAX RANGE SKEWNESS KURTOSIS;BY GROUP;

NOTE: THE PROCEDURE MEANS USED 1.07 SECONDS AND 146K AND PRINTED PAGES 1 TO 8.

296        PROC ANOVA;
297        CLASSES GROUP;
298        MODEL O1T1-O1T18=GROUP;

NOTE: THE PROCEDURE ANOVA USED 0.55 SECONDS AND 172K AND PRINTED PAGES 9 TO 27.

299        PROC ANOVA;
300        CLASSES GROUP;
301        MODEL O2T1-O2T18=GROUP;

NOTE: THE PROCEDURE ANOVA USED 0.53 SECONDS AND 170K AND PRINTED PAGES 28 TO 41.

302        PROC ANOVA;
303        CLASSES GROUP;
304        MODEL O3T1-O3T18=GROUP;

NOTE: THE PROCEDURE ANOVA USED 0.47 SECONDS AND 170K AND PRINTED PAGES 42 TO 52.

305        PROC ANOVA;
306        CLASSES GROUP;
307        MODEL O4T1-O4T18=GROUP;

NOTE: THE PROCEDURE ANOVA USED 0.46 SECONDS AND 170K AND PRINTED PAGES 53 TO 60.

308        PROC ANOVA;
309        CLASSES GROUP;
310        MODEL O5T1-O5T18=GROUP;

NOTE: THE PROCEDURE ANOVA USED 0.49 SECONDS AND 170K AND PRINTED PAGES 61 TO 69.

311        PROC ANOVA;
312        CLASSES GROUP;
313        MODEL O6T1-O6T18=GROUP;

NOTE: THE PROCEDURE ANOVA USED 0.41 SECONDS AND 170K AND PRINTED PAGES 70 TO 75.

NOTE: SAS INSTITUTE INC.
      SAS CIRCLE
      BOX 8000
      CARY, N.C. 27511
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S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   1

GROUP=1

VARIABLE	N	N MISSING	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE	SKEWNESS	KURTOSIS
PITCH1	12	0	1.00000000	0.00000000	1.00000000	1.00000000	0.00000000	.	.
O1T1	12	0	40.66666667	12.41943736	18.00000000	60.00000000	42.00000000	-0.20426818	-0.56552570
O1T2	12	0	36.91666667	12.30060605	18.00000000	62.00000000	44.00000000	0.50980725	-0.15818371
O1T3	12	0	47.41666667	8.03920319	36.00000000	60.00000000	24.00000000	0.10655497	-1.01141785
O1T4	12	0	47.41666667	20.05654884	8.00000000	77.00000000	69.00000000	-0.41636301	-0.07632577
O1T5	12	0	46.91666667	15.46525921	17.00000000	63.00000000	46.00000000	-0.83444939	-0.46556331
O1T6	12	0	20.50000000	11.79753441	3.00000000	44.00000000	41.00000000	0.63859949	-0.14402043
O1T7	12	0	7.16666667	3.95045068	1.00000000	16.00000000	15.00000000	0.72214939	1.27159959
O1T8	12	0	6.25000000	5.62664117	0.00000000	20.00000000	20.00000000	1.44382856	2.38050376
O1T9	12	0	11.50000000	6.64009838	0.00000000	22.00000000	22.00000000	-0.18444640	-0.68877373
O1T10	12	0	15.16666667	9.27198452	3.00000000	29.00000000	26.00000000	0.02341794	-1.71556872
O1T11	12	0	9.33333333	5.12273601	1.00000000	18.00000000	17.00000000	0.11432978	-0.80579287
O1T12	12	0	7.33333333	5.82054876	1.00000000	17.00000000	16.00000000	0.63226738	-0.95017265
O1T13	12	0	7.41666667	5.46822779	0.00000000	20.00000000	20.00000000	1.22161348	1.68041390
O1T14	12	0	2.91666667	1.72986249	1.00000000	7.00000000	6.00000000	1.29051013	1.73924435
O1T15	12	0	3.91666667	2.35326981	0.00000000	8.00000000	8.00000000	0.52097375	0.19638409
O1T16	10	2	1.70000000	1.03734991	1.00000000	4.00000000	3.00000000	1.44400161	1.25785987
O1T17	4	8	3.25000000	2.62995564	1.00000000	7.00000000	6.00000000	1.44305884	2.23486718
O1T18	0	12							
PITCH2	12	0	2.00000000	0.00000000	2.00000000	2.00000000	0.00000000	.	.
O2T1	12	0	27.58333333	14.38091117	5.00000000	49.00000000	44.00000000	-0.38948609	-0.77075811
O2T2	12	0	22.16666667	14.63391660	8.00000000	61.00000000	53.00000000	1.85281292	4.14952165
O2T3	12	0	62.41666667	22.44775078	29.00000000	120.00000000	91.00000000	1.38744126	3.72361275
O2T4	12	0	33.41666667	23.92966335	1.00000000	76.00000000	75.00000000	0.28915483	-1.02611992
O2T5	12	0	8.41666667	6.02205542	1.00000000	20.00000000	19.00000000	0.40335680	-0.67812518
O2T6	12	0	11.58333333	6.22981589	3.00000000	24.00000000	21.00000000	0.69913074	-0.21718709
O2T7	12	0	16.50000000	9.91326017	1.00000000	38.00000000	37.00000000	0.83749569	0.90203638
O2T8	12	0	19.66666667	15.21562196	3.00000000	56.00000000	53.00000000	1.28987024	1.87988646
O2T9	12	0	9.66666667	7.02376917	2.00000000	25.00000000	23.00000000	0.99710563	0.62605751
O2T10	12	0	6.16666667	5.55686853	0.00000000	17.00000000	17.00000000	1.13682259	0.23489865
O2T11	12	0	2.50000000	3.39786029	0.00000000	12.00000000	12.00000000	2.35256900	5.92350011
O2T12	10	2	3.90000000	5.02106673	1.00000000	16.00000000	15.00000000	1.88395295	3.30036297
O2T13	5	7	1.60000000	0.89442719	1.00000000	3.00000000	2.00000000	1.25778824	0.31250000
O2T14	0	12	.	.	.	.	.	.	.
O2T15	0	12	.	.	.	.	.	.	.
O2T16	0	12	.	.	.	.	.	.	.
O2T17	0	12	.	.	.	.	.	.	.
O2T18	0	12	.	.	.	.	.	.	.
PITCH3	12	0	3.00000000	0.00000000	3.00000000	3.00000000	0.00000000	.	.
O3T1	12	0	25.33333333	13.64706651	10.00000000	49.00000000	39.00000000	0.47182666	-1.13780965
O3T2	12	0	52.50000000	12.10935026	32.00000000	77.00000000	45.00000000	0.35848162	0.28694538
O3T3	12	0	35.50000000	18.46126165	6.00000000	63.00000000	57.00000000	-0.19365054	-1.16000145
O3T4	12	0	17.08333333	7.22946412	5.00000000	32.00000000	27.00000000	0.38839866	0.45404025
O3T5	12	0	12.50000000	9.75611696	3.00000000	36.00000000	33.00000000	1.46048993	2.05408312
O3T6	12	0	31.25000000	14.61708216	7.00000000	53.00000000	46.00000000	-0.13210330	-0.72570207
O3T7	12	0	20.33333333	18.40125160	1.00000000	62.00000000	61.00000000	1.22843995	0.94024403
O3T8	12	0	4.33333333	2.99494524	1.00000000	12.00000000	11.00000000	1.53862850	3.38738130
O3T9	10	2	3.10000000	3.07137320	1.00000000	11.00000000	10.00000000	2.24114485	5.40475507
O3T10	3	9	2.33333333	1.15470054	1.00000000	3.00000000	2.00000000	-1.73205081	.
O3T11	0	12	.	.	.	.	.	.	.
O3T12	0	12	.	.	.	.	.	.	.
O3T13	0	12	.	.	.	.	.	.	.
O3T14	0	12	.	.	.	.	.	.	.
O3T15	0	12	.	.	.	.	.	.	.
O3T16	0	12	.	.	.	.	.	.	.
O3T17	0	12	.	.	.	.	.	.	.
O3T18	0	12	.	.	.	.	.	.	.
PITCH4	12	0	4.00000000	0.00000000	4.00000000	4.00000000	0.00000000	.	.
O4T1	12	0	40.83333333	19.25349240	5.00000000	65.00000000	60.00000000	-0.89475911	-0.31067766
O4T2	12	0	72.33333333	13.68697678	45.00000000	98.00000000	53.00000000	-0.05791080	0.78813143
O4T3	12	0	4.75000000	2.98861476	0.00000000	9.00000000	9.00000000	-0.42144675	-0.91453360
O4T4	12	0	9.00000000	4.45176165	2.00000000	16.00000000	14.00000000	0.15579854	-0.99463850
O4T5	12	0	8.91666667	5.10718448	1.00000000	19.00000000	18.00000000	0.18567978	0.13353166
O4T6	11	1	4.45454545	5.22232968	1.00000000	18.00000000	17.00000000	2.05787255	4.40603778
O4T7	5	7	2.20000000	3.27108545	0.00000000	8.00000000	8.00000000	2.13424826	4.67901127
O4T8	0	12	.	.	.	.	.	.	.
O4T9	0	12	.	.	.	.	.	.	.
O4T10	0	12	.	.	.	.	.	.	.
O4T11	0	12	.	.	.	.	.	.	.
O4T12	0	12	.	.	.	.	.	.	.
O4T13	0	12	.	.	.	.	.	.	.
O4T14	0	12	.	.	.	.	.	.	.
O4T15	0	12	.	.	.	.	.	.	.
O4T16	0	12	.	.	.	.	.	.	.

GROUP=1

VARIABLE	N	N MISSING	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE	SKEWNESS	KURTOSIS
O4T17	0	12	.	.	.	.	.	.	.
O4T18	0	12	.	.	.	.	.	.	.
PITCH5	12	0	5.00000000	0.00000000	5.00000000	5.00000000	0.00000000	.	.
O5T1	12	0	64.75000000	10.82190539	45.00000000	90.00000000	45.00000000	0.69646563	2.50775722
O5T2	12	0	43.00000000	12.86997916	16.00000000	60.00000000	44.00000000	-0.85021593	0.36313484
O5T3	12	0	13.25000000	10.19915326	2.00000000	30.00000000	28.00000000	0.68816519	-1.17969674
O5T4	12	0	23.66666667	13.02677895	5.00000000	44.00000000	39.00000000	0.41172331	-0.93133745
O5T5	12	0	12.16666667	6.10265715	2.00000000	20.00000000	18.00000000	-0.41129758	-1.05984279
O5T6	7	5	1.57142857	0.97590007	1.00000000	3.00000000	2.00000000	1.22963409	-0.84000000
O5T7	0	12	.	.	.	.	.	.	.
O5T8	0	12	.	.	.	.	.	.	.
O5T9	0	12	.	.	.	.	.	.	.
O5T10	0	12	.	.	.	.	.	.	.
O5T11	0	12	.	.	.	.	.	.	.
O5T12	0	12	.	.	.	.	.	.	.
O5T13	0	12	.	.	.	.	.	.	.
O5T14	0	12	.	.	.	.	.	.	.
O5T15	0	12	.	.	.	.	.	.	.
O5T16	0	12	.	.	.	.	.	.	.
O5T17	0	12	.	.	.	.	.	.	.
O5T18	0	12	.	.	.	.	.	.	.
PITCH6	12	0	6.00000000	0.00000000	6.00000000	6.00000000	0.00000000	.	.
O6T1	12	0	67.33333333	19.02311194	24.00000000	85.00000000	61.00000000	-1.21940361	0.89371975
O6T2	12	0	46.08333333	21.48343266	6.00000000	72.00000000	66.00000000	-0.82604397	-0.07876758
O6T3	12	0	12.50000000	14.44425019	3.00000000	83.00000000	80.00000000	2.34788705	5.90313211
O6T4	12	0	16.91666667	11.66547613	2.00000000	40.00000000	38.00000000	0.91749272	0.12159577
O6T5	3	9	1.00000000	0.00000000	1.00000000	1.00000000	0.00000000	.	.
O6T6	0	12	.	.	.	.	.	.	.
O6T7	0	12	.	.	.	.	.	.	.
O6T8	0	12	.	.	.	.	.	.	.
O6T9	0	12	.	.	.	.	.	.	.
O6T10	0	12	.	.	.	.	.	.	.
O6T11	0	12	.	.	.	.	.	.	.
O6T12	0	12	.	.	.	.	.	.	.
O6T13	0	12	.	.	.	.	.	.	.
O6T14	0	12	.	.	.	.	.	.	.
O6T15	0	12	.	.	.	.	.	.	.
O6T16	0	12	.	.	.	.	.	.	.
O6T17	0	12	.	.	.	.	.	.	.
O6T18	0	12	.	.	.	.	.	.	.

GROUP=2

VARIABLE	N	N MISSING	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE	SKEWNESS	KURTOSIS
PITCH1	12	0	1.00000000	0.00000000	1.00000000	1.00000000	0.00000000		
01T1	12	0	40.25000000	12.70737080	23.00000000	67.00000000	44.00000000	1.17401096	1.08054037
01T2	12	0	38.41666667	13.96396879	17.00000000	55.00000000	38.00000000	-0.52913512	-1.53808412
01T3	12	0	45.33333333	17.58270500	12.00000000	63.00000000	51.00000000	-1.06401451	0.04826219
01T4	12	0	48.33333333	23.64253999	18.00000000	104.00000000	86.00000000	1.05213018	1.59483145
01T5	12	0	62.33333333	23.87213413	12.00000000	115.00000000	103.00000000	0.15299171	2.89323993
01T6	12	0	18.00000000	11.45743109	5.00000000	40.00000000	35.00000000	0.57444966	-0.71728476
01T7	12	0	6.00000000	5.98482931	0.00000000	16.00000000	16.00000000	0.58930729	-1.37763835
01T8	12	0	6.66666667	6.49941722	0.00000000	20.00000000	20.00000000	1.26319680	0.60088368
01T9	12	0	14.25000000	9.30420237	2.00000000	36.00000000	34.00000000	1.10880714	1.60767358
01T10	12	0	13.16666667	7.73226220	7.00000000	30.00000000	23.00000000	1.51287187	1.37953163
01T11	12	0	10.58333333	4.98102460	2.00000000	19.00000000	17.00000000	0.11212016	-0.50738459
01T12	12	0	8.00000000	5.29150262	2.00000000	18.00000000	16.00000000	0.86588225	-0.33432282
01T13	12	0	8.50000000	3.89638527	3.00000000	13.00000000	10.00000000	-0.33195207	-1.99687332
01T14	12	0	4.58333333	3.08834564	1.00000000	10.00000000	9.00000000	0.84815003	-0.44597898
01T15	12	0	4.66666667	4.35542156	0.00000000	14.00000000	14.00000000	1.10266155	0.45254621
01T16	12	0	2.16666667	1.52752523	0.00000000	5.00000000	5.00000000	0.58473731	-0.64786642
01T17	10	2	1.40000000	0.69920590	1.00000000	3.00000000	2.00000000	1.65772473	2.04545455
01T18	1	11	1.00000000		1.00000000	1.00000000	0.00000000		
PITCH2	12	0	2.00000000	0.00000000	2.00000000	2.00000000	0.00000000	.	
02T1	12	0	30.91666667	12.85908475	17.00000000	53.00000000	36.00000000	0.60846193	-1.23474520
02T2	12	0	41.33333333	21.61789382	17.00000000	88.00000000	71.00000000	0.62740236	0.32024238
02T3	12	0	46.25000000	23.14038186	2.00000000	75.00000000	73.00000000	-0.73133326	-0.65747599
02T4	12	0	42.91666667	15.91145004	11.00000000	70.00000000	59.00000000	-0.19906355	0.28323819
02T5	12	0	16.50000000	5.69688910	8.00000000	27.00000000	19.00000000	0.10443559	-0.23496771
02T6	12	0	18.08333333	8.61772311	2.00000000	35.00000000	33.00000000	-0.00907439	0.59295162
02T7	12	0	19.91666667	10.21103087	6.00000000	38.00000000	32.00000000	0.34651298	-0.55884563
02T8	12	0	20.66666667	11.64890423	5.00000000	48.00000000	43.00000000	1.17192398	1.85415566
02T9	12	0	13.58333333	6.97343444	5.00000000	28.00000000	23.00000000	0.68666890	-0.19216065
02T10	12	0	8.75000000	8.86386946	1.00000000	30.00000000	29.00000000	1.45545404	1.76298703
02T11	11	1	4.45454545	4.88597250	0.00000000	14.00000000	14.00000000	0.92045838	-0.43653047
02T12	11	1	2.72727273	1.90215189	0.00000000	7.00000000	7.00000000	1.11572481	1.78976962
02T13	4	8	3.00000000	0.81649658	2.00000000	4.00000000	2.00000000	0.00000000	1.50000000
02T14	0	12	.	.	.	.	.	.	.
02T15	0	12	.	.	.	.	.	.	.
02T16	0	12	.	.	.	.	.	.	.
02T17	0	12	.	.	.	.	.	.	.
02T18	0	12	.	.	.	.	.	.	.
PITCH3	12	0	3.00000000	0.00000000	3.00000000	3.00000000	0.00000000	.	.
03T1	12	0	30.66666667	10.79000660	16.00000000	48.00000000	32.00000000	0.13226807	-1.00501330
03T2	12	0	48.08333333	14.29213600	10.00000000	62.00000000	52.00000000	-1.87559044	4.30329797
03T3	12	0	43.83333333	21.80422533	4.00000000	80.00000000	76.00000000	-0.27684694	-0.27956344
03T4	12	0	11.58333333	6.45907865	2.00000000	22.00000000	20.00000000	0.48317485	-0.76728233
03T5	12	0	13.25000000	6.91671230	2.00000000	30.00000000	28.00000000	0.97654623	2.73933458
03T6	12	0	32.08333333	19.56554640	1.00000000	60.00000000	59.00000000	0.17807641	-0.98220961
03T7	12	0	25.25000000	17.28438602	3.00000000	54.00000000	51.00000000	0.23801332	-1.40503957
03T8	12	0	13.16666667	11.33645233	1.00000000	33.00000000	32.00000000	1.01378816	-0.49174219
03T9	10	2	5.70000000	2.54077853	2.00000000	10.00000000	8.00000000	-0.08840311	-0.36420084
03T10	1	11	1.00000000		1.00000000	1.00000000	0.00000000	.	.
03T11	0	12	.	.	.	.	.	.	.
03T12	0	12	.	.	.	.	.	.	.
03T13	0	12	.	.	.	.	.	.	.
03T14	0	12	.	.	.	.	.	.	.
03T15	0	12	.	.	.	.	.	.	.
03T16	0	12	.	.	.	.	.	.	.
03T17	0	12	.	.	.	.	.	.	.
03T18	0	12	.	.	.	.	.	.	.
PITCH4	12	0	4.00000000	0.00000000	4.00000000	4.00000000	0.00000000	.	.
04T1	12	0	47.41666667	12.92958787	26.00000000	62.00000000	36.00000000	-0.49978127	-1.42361263
04T2	12	0	75.41666667	13.91178920	36.00000000	87.00000000	51.00000000	-2.43002059	6.34791789
04T3	12	0	3.75000000	3.86417109	0.00000000	13.00000000	13.00000000	1.44141211	1.76039143
04T4	12	0	10.25000000	8.58248745	2.00000000	26.00000000	24.00000000	0.86266668	-0.66124626
04T5	12	0	14.50000000	8.88819442	4.00000000	33.00000000	29.00000000	0.61011096	-0.03685889
04T6	11	1	5.00000000	4.42718872	0.00000000	15.00000000	15.00000000	1.30993280	1.37303901
04T7	6	6	1.33333333	0.51639778	1.00000000	2.00000000	1.00000000	0.96824584	-1.87500000
04T8	0	12	.	.	.	.	.	.	.
04T9	0	12	.	.	.	.	.	.	.
04T10	0	12	.	.	.	.	.	.	.
04T11	0	12	.	.	.	.	.	.	.
04T12	0	12	.	.	.	.	.	.	.
04T13	0	12	.	.	.	.	.	.	.
04T14	0	12	.	.	.	.	.	.	.
04T15	0	12	.	.	.	.	.	.	.
04T16	0	12	.	.	.	.	.	.	.

STATISTICAL ANALYSIS SYSTEM 18.06 TUESDAY, NOVEMBER 4, 1980 4

GROUP=2

VARIABLE	N	N MISSING	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE	SKEWNESS	KURTOSIS
04T17	0	12	.	.	.	.	.	.	.
04T18	0	12	.	.	.	.	.	.	.
PITCH5	12	0	5.00000000	0.00000000	5.00000000	5.00000000	0.00000000	.	.
05T1	12	0	61.08333333	14.08066588	41.00000000	90.00000000	49.00000000	0.54847272	0.10628710
05T2	12	0	46.66666667	21.88537633	8.00000000	73.00000000	65.00000000	-0.76519601	-0.74753675
05T3	12	0	15.00000000	9.40019342	1.00000000	32.00000000	31.00000000	0.09219668	-0.82165151
05T4	12	0	19.75000000	14.59218346	5.00000000	53.00000000	48.00000000	1.24421487	1.26752300
05T5	12	0	18.66666667	10.94061103	8.00000000	44.00000000	36.00000000	1.31645622	1.29486057
05T6	8	4	4.62500000	3.50253009	1.00000000	10.00000000	9.00000000	1.02857061	-0.54781564
05T7	1	11	1.00000000	.	1.00000000	1.00000000	0.00000000	.	.
05T8	0	12	.	.	.	.	.	.	.
05T9	0	12	.	.	.	.	.	.	.
05T10	0	12	.	.	.	.	.	.	.
05T11	0	12	.	.	.	.	.	.	.
05T12	0	12	.	.	.	.	.	.	.
05T13	0	12	.	.	.	.	.	.	.
05T14	0	12	.	.	.	.	.	.	.
05T15	0	12	.	.	.	.	.	.	.
05T16	0	12	.	.	.	.	.	.	.
05T17	0	12	.	.	.	.	.	.	.
05T18	0	12	.	.	.	.	.	.	.
PITCH6	12	0	6.00000000	0.00000000	6.00000000	6.00000000	0.00000000	.	.
06T1	12	0	75.50000000	16.32343547	40.00000000	90.00000000	50.00000000	-1.30895439	0.81562679
06T2	12	0	53.08333333	15.97417423	20.00000000	73.00000000	53.00000000	-0.87270462	0.25198604
06T3	12	0	14.50000000	10.22919174	2.00000000	30.00000000	28.00000000	0.57605872	-1.39902159
06T4	12	0	13.16666667	7.96393385	1.00000000	24.00000000	23.00000000	-0.15396694	-1.61479881
06T5	5	7	1.60000000	0.54772256	1.00000000	2.00000000	1.00000000	-0.60858062	-3.33333333
06T6	0	12	.	.	.	.	.	.	.
06T7	0	12	.	.	.	.	.	.	.
06T8	0	12	.	.	.	.	.	.	.
06T9	0	12	.	.	.	.	.	.	.
06T10	0	12	.	.	.	.	.	.	.
06T11	0	12	.	.	.	.	.	.	.
06T12	0	12	.	.	.	.	.	.	.
06T13	0	12	.	.	.	.	.	.	.
06T14	0	12	.	.	.	.	.	.	.
06T15	0	12	.	.	.	.	.	.	.
06T16	0	12	.	.	.	.	.	.	.
06T17	0	12	.	.	.	.	.	.	.
06T18	0	12	.	.	.	.	.	.	.

GROUP=3

VARIABLE	N	N MISSING	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE	SKEWNESS	KURTOSIS
PITCH1	12	0	1.00000000	0.00000000	1.00000000	1.00000000	0.00000000	.	.
O1T1	12	0	43.66666667	5.69422087	37.00000000	57.00000000	20.00000000	1.42108138	1.87545148
O1T2	12	0	31.41666667	13.45334249	11.00000000	53.00000000	42.00000000	-0.09491378	-0.94673520
O1T3	12	0	32.33333333	12.33128566	12.00000000	51.00000000	39.00000000	0.06451364	-0.75216568
O1T4	12	0	41.66666667	27.62519711	9.00000000	106.00000000	97.00000000	0.97030591	1.37380181
O1T5	12	0	60.83333333	11.35247937	38.00000000	79.00000000	41.00000000	-0.49084863	0.60621087
O1T6	12	0	21.66666667	9.04868984	6.00000000	37.00000000	31.00000000	0.07731836	-0.20097408
O1T7	12	0	5.00000000	4.80530010	0.00000000	14.00000000	14.00000000	0.73737478	-0.96155372
O1T8	12	0	4.08333333	5.38446137	0.00000000	19.00000000	19.00000000	2.20913631	5.46813777
O1T9	12	0	11.75000000	7.02107218	5.00000000	25.00000000	20.00000000	0.98967046	-0.08353579
O1T10	12	0	13.91666667	6.69407246	5.00000000	28.00000000	23.00000000	0.76453736	0.46020306
O1T11	12	0	11.66666667	7.21530360	3.00000000	23.00000000	20.00000000	0.52423821	-1.19898317
O1T12	12	0	6.16666667	3.27062222	2.00000000	14.00000000	12.00000000	1.16965381	1.90517539
O1T13	12	0	9.25000000	4.80766434	2.00000000	19.00000000	17.00000000	0.60484016	0.07226069
O1T14	12	0	3.91666667	2.50302847	0.00000000	9.00000000	9.00000000	0.36338084	0.15590741
O1T15	12	0	2.66666667	1.66969422	1.00000000	6.00000000	5.00000000	0.77598171	-0.23081289
O1T16	10	2	1.90000000	1.52388393	0.00000000	5.00000000	5.00000000	1.14916638	0.81915316
O1T17	5	7	1.40000000	0.54772256	1.00000000	2.00000000	1.00000000	0.60858062	-3.33333333
O1T18	0	12	.	.	.	.	.	.	.
PITCH2	12	0	2.00000000	0.00000000	2.00000000	2.00000000	0.00000000	.	.
O2T1	12	0	33.16666667	18.78022816	15.00000000	77.00000000	62.00000000	1.15400151	1.33830081
O2T2	12	0	36.91666667	14.96941326	5.00000000	55.00000000	50.00000000	-0.75992861	0.31048923
O2T3	12	0	46.66666667	23.80348841	5.00000000	77.00000000	72.00000000	-0.32752579	-1.00175839
O2T4	12	0	41.58333333	22.57294573	18.00000000	95.00000000	77.00000000	1.25915169	1.66923630
O2T5	12	0	10.16666667	5.90582660	2.00000000	20.00000000	18.00000000	0.37607355	-0.98491773
O2T6	12	0	11.33333333	7.81994342	1.00000000	30.00000000	29.00000000	1.43101875	2.19069828
O2T7	12	0	22.91666667	14.43139465	6.00000000	50.00000000	44.00000000	0.68824291	-0.35405381
O2T8	12	0	25.33333333	14.72371824	2.00000000	46.00000000	44.00000000	0.10030619	-1.23628848
O2T9	12	0	21.58333333	11.41337599	8.00000000	41.00000000	33.00000000	0.64998517	-0.98437210
O2T10	12	0	8.25000000	4.47467622	2.00000000	17.00000000	15.00000000	0.34290587	-0.15604288
O2T11	12	0	2.16666667	2.97972950	0.00000000	9.00000000	9.00000000	1.61271711	1.62937716
O2T12	11	1	3.54545455	2.29624199	1.00000000	8.00000000	7.00000000	0.56464072	-0.40219976
O2T13	3	9	1.33333333	0.57735027	1.00000000	2.00000000	1.00000000	1.73205081	.
O2T14	0	12	.	.	.	.	.	.	.
O2T15	0	12	.	.	.	.	.	.	.
O2T16	0	12	.	.	.	.	.	.	.
O2T17	0	12	.	.	.	.	.	.	.
O2T18	0	12	.	.	.	.	.	.	.
PITCH3	12	0	3.00000000	0.00000000	3.00000000	3.00000000	0.00000000	.	.
O3T1	12	0	35.00000000	15.22557657	13.00000000	57.00000000	44.00000000	0.02262447	-1.56575920
O3T2	12	0	47.58333333	14.59425998	23.00000000	60.00000000	37.00000000	-0.81733902	-1.35028647
O3T3	12	0	35.66666667	12.38278375	9.00000000	55.00000000	46.00000000	-0.53795205	0.78899124
O3T4	12	0	12.08333333	5.46822779	6.00000000	22.00000000	16.00000000	0.79846750	-0.90748550
O3T5	12	0	15.25000000	6.90355640	7.00000000	32.00000000	25.00000000	1.15969337	2.25853997
O3T6	12	0	43.25000000	24.04588417	12.00000000	105.00000000	93.00000000	1.58306380	3.51612416
O3T7	12	0	17.25000000	9.85462513	3.00000000	34.00000000	31.00000000	0.44520371	-0.86541799
O3T8	12	0	5.00000000	4.19956708	1.00000000	12.00000000	11.00000000	1.03397992	-0.58536508
O3T9	9	3	3.11111111	2.26077666	1.00000000	8.00000000	7.00000000	1.24283953	1.93191331
O3T10	2	10	3.50000000	3.53553391	1.00000000	6.00000000	5.00000000	.	.
O3T11	0	12	.	.	.	.	.	.	.
O3T12	0	12	.	.	.	.	.	.	.
O3T13	0	12	.	.	.	.	.	.	.
O3T14	0	12	.	.	.	.	.	.	.
O3T15	0	12	.	.	.	.	.	.	.
O3T16	0	12	.	.	.	.	.	.	.
O3T17	0	12	.	.	.	.	.	.	.
O3T18	0	12	.	.	.	.	.	.	.
PITCH4	12	0	4.00000000	0.00000000	4.00000000	4.00000000	0.00000000	.	.
O4T1	12	0	50.16666667	14.71445383	22.00000000	68.00000000	46.00000000	-0.70821859	-0.61567572
O4T2	12	0	77.16666667	9.26217463	59.00000000	90.00000000	31.00000000	-0.55135505	-0.27090222
O4T3	12	0	5.58333333	3.47610894	1.00000000	12.00000000	11.00000000	0.43636872	-0.82130797
O4T4	12	0	18.41666667	11.79721333	2.00000000	38.00000000	36.00000000	0.44320816	-0.68150307
O4T5	12	0	11.25000000	6.32635181	3.00000000	22.00000000	19.00000000	0.52570924	-1.16563810
O4T6	11	1	4.54545455	2.06705764	1.00000000	8.00000000	7.00000000	-0.07891438	-0.25827675
O4T7	5	7	1.00000000	0.00000000	1.00000000	1.00000000	0.00000000	.	.
O4T8	0	12	.	.	.	.	.	.	.
O4T9	0	12	.	.	.	.	.	.	.
O4T10	0	12	.	.	.	.	.	.	.
O4T11	0	12	.	.	.	.	.	.	.
O4T12	0	12	.	.	.	.	.	.	.
O4T13	0	12	.	.	.	.	.	.	.
O4T14	0	12	.	.	.	.	.	.	.
O4T15	0	12	.	.	.	.	.	.	.
O4T16	0	12	.	.	.	.	.	.	.

GROUP=3

VARIABLE	N	N MISSING	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE	SKEWNESS	KURTOSIS
04T17	0	12	.	.	.	.	.	.	.
04T18	0	12	.	.	.	.	.	.	.
PITCH5	12	0	5.00000000	0.00000000	5.00000000	5.00000000	0.00000000	.	.
05T1	12	0	59.66666667	16.80007215	26.00000000	80.00000000	54.00000000	-0.91150155	0.47157760
05T2	12	0	41.66666667	21.17602990	2.00000000	66.00000000	64.00000000	-0.91066303	-0.34624797
05T3	12	0	14.66666667	10.95721708	2.00000000	35.00000000	33.00000000	0.54756587	-0.82420177
05T4	12	0	22.33333333	14.37379771	3.00000000	45.00000000	42.00000000	0.11346875	-1.54028298
05T5	12	0	13.41666667	7.95965204	4.00000000	28.00000000	24.00000000	0.93516911	-0.44638758
05T6	6	6	1.33333333	0.81649658	1.00000000	3.00000000	2.00000000	2.44948974	6.00000000
05T7	0	12	.	.	.	.	.	.	.
05T8	0	12	.	.	.	.	.	.	.
05T9	0	12	.	.	.	.	.	.	.
05T10	0	12	.	.	.	.	.	.	.
05T11	0	12	.	.	.	.	.	.	.
05T12	0	12	.	.	.	.	.	.	.
05T13	0	12	.	.	.	.	.	.	.
05T14	0	12	.	.	.	.	.	.	.
05T15	0	12	.	.	.	.	.	.	.
05T16	0	12	.	.	.	.	.	.	.
05T17	0	12	.	.	.	.	.	.	.
05T18	0	12	.	.	.	.	.	.	.
PITCH6	12	0	6.00000000	0.00000000	6.00000000	6.00000000	0.00000000	.	.
06T1	12	0	70.91666667	21.65203469	14.00000000	95.00000000	81.00000000	-1.66380333	3.98151359
06T2	12	0	43.41666667	16.59933369	24.00000000	78.00000000	54.00000000	0.68910671	-0.06644522
06T3	12	0	23.16666667	16.66151436	4.00000000	48.00000000	44.00000000	0.40074391	-1.45164763
06T4	12	0	18.00000000	11.04536102	3.00000000	38.00000000	35.00000000	0.59745497	-0.44032233
06T5	3	9	1.00000000	0.00000000	1.00000000	1.00000000	0.00000000	.	.
06T6	0	12	.	.	.	.	.	.	.
06T7	0	12	.	.	.	.	.	.	.
06T8	0	12	.	.	.	.	.	.	.
06T9	0	12	.	.	.	.	.	.	.
06T10	0	12	.	.	.	.	.	.	.
06T11	0	12	.	.	.	.	.	.	.
06T12	0	12	.	.	.	.	.	.	.
06T13	0	12	.	.	.	.	.	.	.
06T14	0	12	.	.	.	.	.	.	.
06T15	0	12	.	.	.	.	.	.	.
06T16	0	12	.	.	.	.	.	.	.
06T17	0	12	.	.	.	.	.	.	.
06T18	0	12	.	.	.	.	.	.	.

GROUP=4

VARIABLE	N	N MISSING	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE	SKEWNESS	KURTOSIS
PITCH1	12	0	1.00000000	0.00000000	1.00000000	1.00000000	0.00000000	.	.
Q1T1	12	0	41.00000000	13.21156918	14.00000000	69.00000000	55.00000000	-0.01362443	2.20541406
Q1T2	12	0	36.33333333	16.13766533	11.00000000	58.00000000	47.00000000	-0.37345652	-1.18732859
Q1T3	12	0	37.33333333	12.99183893	12.00000000	56.00000000	44.00000000	-0.35993318	-0.41108272
Q1T4	12	0	47.41666667	29.77323931	12.00000000	118.00000000	106.00000000	1.03450996	1.73778755
Q1T5	12	0	49.75000000	13.09493309	29.00000000	73.00000000	44.00000000	0.15837246	-0.51343410
Q1T6	12	0	17.58333333	12.58034783	4.00000000	41.00000000	37.00000000	0.77913127	-0.68035533
Q1T7	12	0	5.16666667	3.90415474	1.00000000	13.00000000	12.00000000	0.91679872	-0.11947401
Q1T8	12	0	3.08333333	1.88092498	1.00000000	6.00000000	5.00000000	0.44695309	-1.26002504
Q1T9	12	0	9.33333333	6.70594490	3.00000000	23.00000000	20.00000000	1.11812926	0.15322687
Q1T10	12	0	12.75000000	5.25919109	3.00000000	20.00000000	17.00000000	-0.38444259	-0.83944341
Q1T11	12	0	11.16666667	7.00432767	4.00000000	30.00000000	26.00000000	1.84447866	4.68981646
Q1T12	12	0	6.00000000	3.07482446	1.00000000	10.00000000	9.00000000	-0.13509214	-1.14230769
Q1T13	12	0	6.08333333	3.20392751	2.00000000	13.00000000	11.00000000	0.76543508	0.73307891
Q1T14	12	0	3.16666667	2.75790874	0.00000000	8.00000000	8.00000000	0.44782474	-0.89381430
Q1T15	12	0	1.66666667	2.01509455	0.00000000	7.00000000	7.00000000	1.98798123	4.21303184
Q1T16	10	2	1.60000000	1.34989712	0.00000000	5.00000000	5.00000000	1.93781706	4.92277131
Q1T17	7	5	1.57142857	1.13389342	1.00000000	4.00000000	3.00000000	2.15579736	4.58024691
Q1T18	0	12	.	.	.	.	.	.	.
PITCH2	12	0	2.00000000	0.00000000	2.00000000	2.00000000	0.00000000	.	.
Q2T1	12	0	31.91666667	18.29286166	9.00000000	68.00000000	59.00000000	0.59230088	-0.47215102
Q2T2	12	0	42.66666667	20.85156778	8.00000000	82.00000000	74.00000000	0.01259984	0.27520824
Q2T3	12	0	51.33333333	23.07431998	9.00000000	82.00000000	73.00000000	-0.49328122	-0.63742070
Q2T4	12	0	44.50000000	25.50044563	10.00000000	100.00000000	90.00000000	0.62925357	0.66556644
Q2T5	12	0	9.83333333	4.50924975	4.00000000	17.00000000	13.00000000	0.54479836	-0.96449146
Q2T6	12	0	10.33333333	6.34369169	0.00000000	20.00000000	20.00000000	0.06362454	-1.10744484
Q2T7	12	0	16.08333333	11.92749561	6.00000000	37.00000000	31.00000000	0.98323006	-0.77924746
Q2T8	12	0	18.83333333	8.46203643	5.00000000	35.00000000	30.00000000	0.26499575	0.06771899
Q2T9	12	0	10.75000000	7.13665315	1.00000000	26.00000000	25.00000000	0.90499488	0.77732605
Q2T10	12	0	4.08333333	5.79110976	1.00000000	22.00000000	21.00000000	3.16041319	10.45150749
Q2T11	12	0	1.83333333	2.36771210	0.00000000	8.00000000	8.00000000	2.01266252	3.90349744
Q2T12	11	1	3.36363636	3.47196565	1.00000000	13.00000000	12.00000000	2.48213817	6.85746720
Q2T13	3	9	1.66666667	1.15470054	1.00000000	3.00000000	2.00000000	1.73205081	.
Q2T14	0	12	.	.	.	.	.	.	.
Q2T15	0	12	.	.	.	.	.	.	.
Q2T16	0	12	.	.	.	.	.	.	.
Q2T17	0	12	.	.	.	.	.	.	.
Q2T18	0	12	.	.	.	.	.	.	.
PITCH3	12	0	3.00000000	0.00000000	3.00000000	3.00000000	0.00000000	.	.
Q3T1	12	0	28.25000000	17.59713303	9.00000000	54.00000000	45.00000000	0.45389462	-1.48864568
Q3T2	12	0	49.08333333	12.58034783	25.00000000	63.00000000	38.00000000	-0.73520092	-0.38543385
Q3T3	12	0	44.58333333	15.64642471	7.00000000	59.00000000	52.00000000	-1.52454535	1.99463605
Q3T4	12	0	8.16666667	4.10838020	0.00000000	15.00000000	15.00000000	-0.19017922	0.51077038
Q3T5	12	0	12.91666667	6.78847062	3.00000000	24.00000000	21.00000000	0.26353779	-1.09281830
Q3T6	12	0	34.33333333	14.04753834	10.00000000	60.00000000	50.00000000	0.02970783	-0.21593939
Q3T7	12	0	16.66666667	11.03987264	2.00000000	38.00000000	36.00000000	0.58659935	-0.56703548
Q3T8	12	0	3.91666667	2.90636710	0.00000000	9.00000000	9.00000000	0.87199920	-0.16735378
Q3T9	10	2	4.60000000	3.56526452	1.00000000	11.00000000	10.00000000	0.96208007	-0.34602417
Q3T10	2	10	4.00000000	2.82842712	2.00000000	6.00000000	4.00000000	.	.
Q3T11	0	12	.	.	.	.	.	.	.
Q3T12	0	12	.	.	.	.	.	.	.
Q3T13	0	12	.	.	.	.	.	.	.
Q3T14	0	12	.	.	.	.	.	.	.
Q3T15	0	12	.	.	.	.	.	.	.
Q3T16	0	12	.	.	.	.	.	.	.
Q3T17	0	12	.	.	.	.	.	.	.
Q3T18	0	12	.	.	.	.	.	.	.
PITCH4	12	0	4.00000000	0.00000000	4.00000000	4.00000000	0.00000000	.	.
Q4T1	12	0	52.00000000	10.86278049	34.00000000	67.00000000	33.00000000	-0.29974704	-1.19626805
Q4T2	12	0	82.75000000	11.39477552	53.00000000	95.00000000	42.00000000	-1.70589571	3.72544679
Q4T3	12	0	3.50000000	1.93061460	0.00000000	6.00000000	6.00000000	-0.40932245	-0.76954194
Q4T4	12	0	12.50000000	9.37598480	0.00000000	34.00000000	34.00000000	1.04348087	1.47175481
Q4T5	12	0	9.08333333	6.51513390	4.00000000	26.00000000	22.00000000	1.80758455	3.59120408
Q4T6	11	1	2.36363636	1.62927759	0.00000000	5.00000000	5.00000000	0.12751821	-1.35203603
Q4T7	3	9	1.33333333	0.57735027	1.00000000	2.00000000	1.00000000	1.73205081	.
Q4T8	0	12	.	.	.	.	.	.	.
Q4T9	0	12	.	.	.	.	.	.	.
Q4T10	0	12	.	.	.	.	.	.	.
Q4T11	0	12	.	.	.	.	.	.	.
Q4T12	0	12	.	.	.	.	.	.	.
Q4T13	0	12	.	.	.	.	.	.	.
Q4T14	0	12	.	.	.	.	.	.	.
Q4T15	0	12	.	.	.	.	.	.	.
Q4T16	0	12	.	.	.	.	.	.	.

GROUP=4

VARIABLE	N	N MISSING	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE	SKEWNESS	KURTOSIS
04T17	0	12	.	.	.	.	.	.	.
04T18	0	12	.	.	.	.	.	.	.
PITCH5	12	0	5.00000000	0.00000000	5.00000000	5.00000000	0.00000000	.	.
05T1	12	0	67.08333333	13.21471861	34.00000000	81.00000000	47.00000000	-1.49899637	2.70439614
05T2	12	0	46.16666667	11.71505118	30.00000000	67.00000000	37.00000000	0.11420070	-0.76266564
05T3	12	0	11.41666667	5.64814263	5.00000000	21.00000000	16.00000000	0.66688450	-0.97087496
05T4	12	0	19.75000000	9.84539579	6.00000000	44.00000000	38.00000000	1.32908276	2.69921498
05T5	12	0	10.83333333	4.08619257	5.00000000	17.00000000	12.00000000	0.24925693	-1.08649207
05T6	8	4	1.00000000	0.00000000	1.00000000	1.00000000	0.00000000	.	.
05T7	1	11	0.00000000	.	0.00000000	0.00000000	0.00000000	.	.
05T8	1	11	1.00000000	.	1.00000000	1.00000000	0.00000000	.	.
05T9	0	12	.	.	.	.	.	.	.
05T10	0	12	.	.	.	.	.	.	.
05T11	0	12	.	.	.	.	.	.	.
05T12	0	12	.	.	.	.	.	.	.
05T13	0	12	.	.	.	.	.	.	.
05T14	0	12	.	.	.	.	.	.	.
05T15	0	12	.	.	.	.	.	.	.
05T16	0	12	.	.	.	.	.	.	.
05T17	0	12	.	.	.	.	.	.	.
05T18	0	12	.	.	.	.	.	.	.
PITCH6	12	0	6.00000000	0.00000000	6.00000000	6.00000000	0.00000000	.	.
D6T1	12	0	87.91666667	7.42793662	76.00000000	98.00000000	22.00000000	-0.04771740	-1.26641397
D6T2	12	0	39.75000000	17.61262460	12.00000000	74.00000000	62.00000000	0.56176360	-0.08500457
D6T3	12	0	16.25000000	15.12448346	3.00000000	51.00000000	48.00000000	1.39848059	1.19532660
D6T4	12	0	12.50000000	8.70214185	1.00000000	29.00000000	28.00000000	0.40673846	-0.55429[illegible]
D6T5	2	10	2.00000000	0.00000000	2.00000000	2.00000000	0.00000000	.	.
D6T6	0	12	.	.	.	.	.	.	.
D6T7	0	12	.	.	.	.	.	.	.
D6T8	0	12	.	.	.	.	.	.	.
D6T9	0	12	.	.	.	.	.	.	.
D6T10	0	12	.	.	.	.	.	.	.
D6T11	0	12	.	.	.	.	.	.	.
D6T12	0	12	.	.	.	.	.	.	.
D6T13	0	12	.	.	.	.	.	.	.
D6T14	0	12	.	.	.	.	.	.	.
D6T15	0	12	.	.	.	.	.	.	.
D6T16	0	12	.	.	.	.	.	.	.
D6T17	0	12	.	.	.	.	.	.	.
D6T18	0	12	.	.	.	.	.	.	.

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   9

ANALYSIS OF VARIANCE PROCEDURE

CLASS LEVEL INFORMATION

CLASS	LEVELS	VALUES
GROUP	4	1 2 3 4

NUMBER OF OBSERVATIONS IN DATA SET = 48

GROUP	OBS	DEPENDENT VARIABLES
1	48	O1T1 O1T2 O1T3 O1T4 O1T5 O1T6 O1T7 O1T8 O1T9 O1T10 O1T11 O1T12 O1T13 O1T14 O1T15
2	42	O1T16
3	26	O1T17
4	1	O1T18

NOTE VARIABLES IN EACH GROUP ARE CONSISTENT WITH RESPECT TO THE PRESENCE OR ABSENCE OF MISSING VALUES.

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18 06 TUESDAY, NOVEMBER 4, 1980   10

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE O1T1

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V
MODEL	3	85 89583333	28 63194444	0 22	0 8826	0 014720	27 6144
ERROR	44	5749 58333333	130 67234848		STD DEV		O1T1 MEAN
CORRECTED TOTAL	47	5835 47916667			11 43120066		41 39583333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	85. 89583333	0 22	0. 8826

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18 06 TUESDAY, NOVEMBER 4, 1980   11

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE. O1T2

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C V.
MODEL	3	331. 06250000	110. 35416667	0 56	0 6463	0. 036580	39 3539
ERROR	44	8719 41666667	198. 16856061		STD DEV		O1T2 MEAN
CORRECTED TOTAL	47	9050 47916667			14. 07723555		35. 77083333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	331. 06250000	0. 56	0. 6463

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   12

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O1T3

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V
MODEL	3	1774. 56250000	591. 52083333	3. 41	0. 0257	0. 188473	32. 4546
ERROR	44	7640. 91666667	173. 65719697		STD DEV		O1T3 MEAN
CORRECTED TOTAL	47	9415. 47916667			13. 17790564		40. 60416667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	1774. 56250000	3. 41	0. 0257

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: OIT4

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	336.75000000	112.25000000	0.17	0.9148	0.011590	55.2891
ERROR	44	28719.16666667	652.70833333		STD DEV		OIT4 MEAN
CORRECTED TOTAL	47	29055.91666667			25.54815714		46.20833333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	336.75000000	0.17	0.9148

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: OIT5

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	2168.41666667	722.80555556	2.61	0.0636	0.150879	30.3028
ERROR	44	12203.50000000	277.35227273		STD DEV		OIT5 MEAN
CORRECTED TOTAL	47	14371.91666667			16.65389662		54.95833333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	2168.41666667	2.61	0.0636

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: OIT6

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	139.22916667	46.40972222	0.36	0.7796	0.024189	58.1259
ERROR	44	5616.58333333	127.64962121		STD DEV		OIT6 MEAN
CORRECTED TOTAL	47	5755.81250000			11.29821319		19.43750000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	139.22916667	0.36	0.7796

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: OIT7

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	35.33333333	11.77777778	0.52	0.6675	0.034550	81.2061
ERROR	44	987.33333333	22.43939394		STD DEV		OIT7 MEAN
CORRECTED TOTAL	47	1022.66666667			4.73702374		5.83333333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	35.33333333	0.52	0.6675

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: Q1T8

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	106.22916667	35.40972222	1.33	0.2765	0.083188	102.7377
ERROR	44	1170.75000000	26.60795455		STD DEV		Q1T8 MEAN
CORRECTED TOTAL	47	1276.97916667			5.15828989		5.02083333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	106.22916667	1.33	0.2765

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: Q1T9

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	145.75000000	48.58333333	0.86	0.4669	0.055632	64.0462
ERROR	44	2474.16666667	56.23106061		STD DEV		Q1T9 MEAN
CORRECTED TOTAL	47	2619.91666667			7.49873727		11.70833333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	145.75000000	0.86	0.4669

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: Q1T10

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	40.50000000	13.50000000	0.25	0.8627	0.016592	53.7182
ERROR	44	2400.50000000	54.55681818		STD DEV		Q1T10 MEAN
CORRECTED TOTAL	47	2441.00000000			7.38625874		13.75000000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	40.50000000	0.25	0.8627

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: Q1T11

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	36.39583333	12.13194444	0.32	0.8116	0.021280	57.7118
ERROR	44	1673.91666667	38.04356061		STD DEV		Q1T11 MEAN
CORRECTED TOTAL	47	1710.31250000			6.16794622		10.68750000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	36.39583333	0.32	0.8116

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE O1T12

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C V
MODEL	3	32 91666667	10. 97222222	0. 54	0 6607	0. 035196	65 8695
ERROR	44	902. 33333333	20. 50757576		STD DEV		O1T12 MEAN
CORRECTED TOTAL	47	935. 25000000			4. 52852909		6. 87500000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	32. 91666667	0 54	0. 6607

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE O1T13

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C. V
MODEL	3	68 22916667	22 74305556	1. 16	0 3360	0. 073261	56 6905
ERROR	44	863 08333333	19 61553030		STD DEV		O1T13 MEAN
CORRECTED TOTAL	47	931 31250000			4. 42894235		7. 81250000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	68 22916667	1. 16	0 3360

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE. O1T14

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C V
MODEL	3	20 56250000	6. 85416667	1 04	0 3849	0 066122	70. 4673
ERROR	44	290. 41666667	6. 60037879		STD DEV		O1T14 MEAN
CORRECTED TOTAL	47	310. 97916667			2. 56912024		3 64583333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	20 56250000	1. 04	0. 3849

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O1T15

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C. V.
MODEL	3	63. 56250000	21. 18750000	2. 70	0. 0569	0. 155608	86. 7042
ERROR	44	344. 91666667	7. 83901515		STD DEV		O1T15 MEAN
CORRECTED TOTAL	47	408. 47916667			2. 79982413		3. 22916667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	63. 56250000	2. 70	0. 0569

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: 01T16

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	2.07619048	0.69206349	0.36	0.7823	0.027630	74.6659
ERROR	38	73.06666667	1.92280702		STD DEV		01T16 MEAN
CORRECTED TOTAL	41	75.14285714			1.38665317		1.85714286

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	2.07619048	0.36	0.7823

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: 01T17

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	11.05109890	3.68369963	2.38	0.0972	0.244952	71.8951
ERROR	22	34.06428571	1.54837662		STD DEV		01T17 MEAN
CORRECTED TOTAL	25	45.11538462			1.24433783		1.73076923

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	11.05109890	2.38	0.0972

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: 01T18

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	0	0	0	99999.99	0.0000	0.000000	0.0000
ERROR	0	0	0		STD DEV		01T18 MEAN
CORRECTED TOTAL	0	0			0		1.00000000

SOURCE	DF	ANOVA SS	F VALUE	PR > F

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ANALYSIS OF VARIANCE PROCEDURE

CLASS LEVEL INFORMATION

CLASS	LEVELS	VALUES
GROUP	4	1 2 3 4

NUMBER OF OBSERVATIONS IN DATA SET = 48

GROUP	OBS	DEPENDENT VARIABLES
0	0	02T14 02T15 02T16 02T17 02T18
1	48	02T1 02T2 02T3 02T4 02T5 02T6 02T7 02T8 02T9 02T10
2	47	02T11
3	43	02T12
4	15	02T13

NOTE: VARIABLES IN EACH GROUP ARE CONSISTENT WITH RESPECT TO THE PRESENCE OR ABSENCE OF MISSING VALUES.

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T1

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	206.06250000	68.68750000	0.26	0.8543	0.017374	52.6760
ERROR	44	11654.41666667	264.87310606		STD DEV		O2T1 MEAN
CORRECTED TOTAL	47	11860.47916667			16.27492261		30.89583333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	206.06250000	0.26	0.8543

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T2

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	3178.56250000	1059.52083333	3.16	0.0338	0.177351	51.1742
ERROR	44	14743.91666667	335.08901515		STD DEV		O2T2 MEAN
CORRECTED TOTAL	47	17922.47916667			18.30543676		35.77083333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	3178.56250000	3.16	0.0338

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T3

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	2040.16666667	680.05555556	1.27	0.2957	0.079810	44.7512
ERROR	44	23522.50000000	534.60227273		STD DEV		O2T3 MEAN
CORRECTED TOTAL	47	25562.66666667			23.12146779		51.66666667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	2040.16666667	1.27	0.2957

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T4

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	877.72916667	292.57638889	0.59	0.6252	0.038633	54.8715
ERROR	44	21841.75000000	496.40340909		STD DEV		O2T4 MEAN
CORRECTED TOTAL	47	22719.47916667			22.28011241		40.60416667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	877.72916667	0.59	0.6252

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T5

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V
MODEL	3	465.22916667	155.07638889	5.01	0.0045	0.254435	49.5694
ERROR	44	1363.25000000	30.98295455		STD DEV		O2T5 MEAN
CORRECTED TOTAL	47	1828.47916667			5.56623343		11.22916667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	465.22916667	5.01	0.0045

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T6

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V
MODEL	3	451.50000000	150.50000000	2.81	0.0505	0.160638	57.0576
ERROR	44	2359.16666667	53.61742424		STD DEV		O2T6 MEAN
CORRECTED TOTAL	47	2810.66666667			7.32239198		12.83333333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	451.50000000	2.81	0.0505

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T7

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	370.22916667	123.40972222	0.89	0.4525	0.057364	62.3666
ERROR	44	6083.75000000	138.26704545		STD DEV		O2T7 MEAN
CORRECTED TOTAL	47	6453.97916667			11.75870084		18.85416667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	370.22916667	0.89	0.4525

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T8

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V
MODEL	3	303.58333333	101.19444444	0.62	0.6074	0.040396	60.6031
ERROR	44	7211.66666667	163.90151515		STD DEV		O2T8 MEAN
CORRECTED TOTAL	47	7515.25000000			12.80240271		21.12500000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	303.58333333	0.62	0.6074

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T9

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	1043.72916667	347.90972222	4.99	0.0046	0.253672	60.1189
ERROR	44	3070.75000000	69.78977273		STD DEV		O2T9 MEAN
CORRECTED TOTAL	47	4114.47916667			8.35402734		13.89583333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	1043.72916667	4.99	0.0046

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T10

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	164.22916667	54.74305556	1.34	0.2726	0.083905	93.7060
ERROR	44	1793.08333333	40.75189394		STD DEV		O2T10 MEAN
CORRECTED TOTAL	47	1957.31250000			6.38372101		6.81250000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	164.22916667	1.34	0.2726

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T11

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	46.76918117	15.58972706	1.28	0.2944	0.081789	129.3197
ERROR	43	525.06060606	12.21071177		STD DEV		O2T11 MEAN
CORRECTED TOTAL	46	571.82978723			3.49438289		2.70212766

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	46.76918117	1.28	0.2944

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T12

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	7.69196617	2.56398872	0.23	0.8755	0.017322	99.1946
ERROR	39	436.35454545	11.18857809		STD DEV		O2T12 MEAN
CORRECTED TOTAL	42	444.04651163			3.34493320		3.37209302

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	7.69196617	0.23	0.8755

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O2T13

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	6.40000000	2.13333333	2.75	0.0932	0.428571	45.5571
ERROR	11	8.53333333	0.77575758		STD DEV		O2T13 MEAN
CORRECTED TOTAL	14	14.93333333			0.88077101		1.93333333

SOURCE	DF	ANOVA SS	F VALUE	PR > F

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ANALYSIS OF VARIANCE PROCEDURE

CLASS LEVEL INFORMATION

CLASS	LEVELS	VALUES
GROUP	4	1 2 3 4

NUMBER OF OBSERVATIONS IN DATA SET = 48

GROUP	OBS	DEPENDENT VARIABLES
0	0	O3T11 O3T12 O3T13 O3T14 O3T15 O3T16 O3T17 O3T18
1	48	O3T1 O3T2 O3T3 O3T4 O3T5 O3T6 O3T7 O3T8
2	39	O3T9
3	8	O3T10

NOTE: VARIABLES IN EACH GROUP ARE CONSISTENT WITH RESPECT TO THE PRESENCE OR ABSENCE OF MISSING VALUES.

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O3T1

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	601.72916667	200.57638889	0.95	0.4245	0.060859	48.7281
ERROR	44	9285.58333333	211.03598485		STD DEV		O3T1 MEAN
CORRECTED TOTAL	47	9887.31250000			14.52707764		29.81250000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	601.72916667	0.95	0.4245

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE O3T2

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	176.56250000	58.85416667	0.33	0.8065	0.021743	27.2477
ERROR	44	7943.75000000	180.53977273		STD DEV		O3T2 MEAN
CORRECTED TOTAL	47	8120.31250000			13.43650895		49.31250000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	176.56250000	0.33	0.8065

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O3T3

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	896.22916667	298.74305556	0.98	0.4090	0.062874	43.6738
ERROR	44	13358.25000000	303.59659091		STD DEV		O3T3 MEAN
CORRECTED TOTAL	47	14254.47916667			17.42402338		39.89583333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	896.22916667	0.98	0.4090

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O3T4

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	486.06250000	162.02083333	4.60	0.0069	0.238912	48.5088
ERROR	44	1548.41666667	35.19128788		STD DEV		O3T4 MEAN
CORRECTED TOTAL	47	2034.47916667			5.93222453		12.22916667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	486.06250000	4.60	0.0069

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O3T5

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	53.56250000	17.85416667	0.30	0.8240	0.020152	57.0776
ERROR	44	2604.41666667	59.19128788		STD DEV		O3T5 MEAN
CORRECTED TOTAL	47	2657.97916667			7.69358745		13.47916667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	53.56250000	0.30	0.8240

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O3T6

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	1090.39583333	363.46527778	1.06	0.3759	0.067381	52.5710
ERROR	44	15092.08333333	343.00189394		STD DEV		O3T6 MEAN
CORRECTED TOTAL	47	16182.47916667			18.52031031		35.22916667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	1090.39583333	1.06	0.3759

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O3T7

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	555.41666667	185.13888889	0.86	0.4665	0.055679	73.6187
ERROR	44	9419.83333333	214.08712121		STD DEV		O3T7 MEAN
CORRECTED TOTAL	47	9975.25000000			14.63171628		19.87500000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	555.41666667	0.86	0.4665

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O3T8

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V
MODEL	3	696.22916667	232.07638889	5.68	0.0022	0.278996	96.8281
ERROR	44	1799.25000000	40.89204545		STD DEV		O3T8 MEAN
CORRECTED TOTAL	47	2495.47916667			6.39468885		6.60416667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	696.22916667	5.68	0.0022

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ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O3T9

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C V
MODEL	3	46.78803419	15.59601140	1.83	0.1597	0.135587	70.2804
ERROR	35	298.28888889	8.52253968		STD DEV		O3T9 MEAN
CORRECTED TOTAL	38	345.07692308			2.91933891		4.15384615

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	46.78803419	1.83	0.1597

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   52

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O3T10

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	7.70833333	2.56944444	0.44	0.7348	0.249663	83.7074
ERROR	4	23.16666667	5.79166667		STD DEV		O3T10 MEAN
CORRECTED TOTAL	7	30.87500000			2.40658818		2.87500000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	7.70833333	0.44	0.7348

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   53

ANALYSIS OF VARIANCE PROCEDURE

CLASS LEVEL INFORMATION

CLASS	LEVELS	VALUES
GROUP	4	1 2 3 4

NUMBER OF OBSERVATIONS IN DATA SET = 48

GROUP	OBS	DEPENDENT VARIABLES
0	0	O4T8 O4T9 O4T10 O4T11 O4T12 O4T13 O4T14 O4T15 O4T16 O4T17 O4T18
1	48	O4T1 O4T2 O4T3 O4T4 O4T5
2	44	O4T6
3	19	O4T7

NOTE: VARIABLES IN EACH GROUP ARE CONSISTENT WITH RESPECT TO THE PRESENCE OR ABSENCE OF MISSING VALUES.

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   54

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O4T1

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	861.22916667	287.07638889	1.32	0.2811	0.082355	31.0227
ERROR	44	9596.25000000	218.09659091		STD DEV		O4T1 MEAN
CORRECTED TOTAL	47	10457.47916667			14.76809368		47.60416667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	861.22916667	1.32	0.2811

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   55

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O4T2

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	688.16666667	229.38888889	1.54	0.2179	0.094924	15.8765
ERROR	44	6561.50000000	149.12500000		STD DEV		O4T2 MEAN
CORRECTED TOTAL	47	7249.66666667			12.21167474		76.91666667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	688.16666667	1.54	0.2179

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   56

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O4T3

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	33.06250000	11.02083333	1.11	0.3548	0.070424	71.6445
ERROR	44	436.41666667	9.91856061		STD DEV		O4T3 MEAN
CORRECTED TOTAL	47	469.47916667			3.14937464		4.39583333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	33.06250000	1.11	0.3548

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   57

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: D4T4

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	627.75000000	209.25000000	2.61	0.0632	0.151122	71.3789
ERROR	44	3526.16666667	80.14015152		STD DEV		D4T4 MEAN
CORRECTED TOTAL	47	4153.91666667			8.95210319		12.54166667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	627.75000000	2.61	0.0632

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   58

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: D4T5

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	243.72916667	81.24305556	1.73	0.1742	0.105656	62.6057
ERROR	44	2063.08333333	46.88825758		STD DEV		D4T5 MEAN
CORRECTED TOTAL	47	2306.81250000			6.84750010		10.93750000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	243.72916667	1.73	0.1742

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   59

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: D4T6

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	45.63636364	15.21212121	1.13	0.3481	0.078193	89.6481
ERROR	40	538.00000000	13.45000000		STD DEV		D4T6 MEAN
CORRECTED TOTAL	43	583.63636364			3.66742416		4.09090909

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	45.63636364	1.13	0.3481

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   60

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: D4T7

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	3.93684211	1.31228070	0.44	0.7282	0.080778	117.2705
ERROR	15	44.80000000	2.98666667		STD DEV		D4T7 MEAN
CORRECTED TOTAL	18	48.73684211			1.72819752		1.47368421

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	3.93684211	0.44	0.7282

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   61

ANALYSIS OF VARIANCE PROCEDURE

CLASS LEVEL INFORMATION

CLASS	LEVELS	VALUES
GROUP	4	1 2 3 4

NUMBER OF OBSERVATIONS IN DATA SET = 48

GROUP	OBS	DEPENDENT VARIABLES
0	0	O5T9 O5T10 O5T11 O5T12 O5T13 O5T14 O5T15 O5T16 O5T17 O5T18
1	48	O5T1 O5T2 O5T3 O5T4 O5T5
2	29	O5T6
3	2	O5T7
4	1	O5T8

NOTE: VARIABLES IN EACH GROUP ARE CONSISTENT WITH RESPECT TO THE PRESENCE OR ABSENCE OF MISSING VALUES.

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   62

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O5T1

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	413.22916667	137.74305556	0.71	0.5492	0.046389	22.0041
ERROR	44	8494.75000000	193.06250000		STD DEV		O5T1 MEAN
CORRECTED TOTAL	47	8907.97916667			13.89469323		63.14583333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	413.22916667	0.71	0.5492

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   63

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O5T2

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	212.25000000	70.75000000	0.23	0.8750	0.015442	39.5214
ERROR	44	13533.00000000	307.56818182		STD DEV		O5T2 MEAN
CORRECTED TOTAL	47	13745.25000000			17.53762190		44.37500000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	212.25000000	0.23	0.8750

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   64

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O5T3

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	95.83333333	31.94444444	0.37	0.7742	0.024676	68.3066
ERROR	44	3787.83333333	86.08712121		STD DEV		O5T3 MEAN
CORRECTED TOTAL	47	3883.66666667			9.27831457		13.58333333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	95.83333333	0.37	0.7742

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   65

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O5T4

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	137.41666667	45.80555556	0.27	0.8488	0.017881	61.2743
ERROR	44	7547.83333333	171.54166667		STD DEV		O5T4 MEAN
CORRECTED TOTAL	47	7685.25000000			13.09739160		21.37500000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	137.41666667	0.27	0.8488

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   66

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O5T5

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	423.56250000	141.18750000	2.38	0.0822	0.139748	55.8955
ERROR	44	2606.91666667	59.24810606		STD DEV		O5T5 MEAN
CORRECTED TOTAL	47	3030.47916667			7.69727913		13.77083333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	423.56250000	2.38	0.0822

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   67

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O5T6

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	65.83600164	21.94533388	5.78	0.0038	0.409533	88.2943
ERROR	25	94.92261905	3.79690476		STD DEV		O5T6 MEAN
CORRECTED TOTAL	28	160.75862069			1.94856480		2.20689655

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	65.83600164	5.78	0.0038

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   68

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O5T7

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	0.50000000	0.50000000	99999.99	0.0000	1.000000	0.0000
ERROR	0	0.00000000	0.00000000		STD DEV	.	O5T7 MEAN
CORRECTED TOTAL	1	0.50000000			0.00000000		0.50000000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	1	0.50000000	.	.

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   69

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE O5T8

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C V
MODEL	0	0	0	99999.99	0.0000	0.000000	0.0000
ERROR	0	0	0		STD DEV		O5T8 MEAN
CORRECTED TOTAL	0	0			0		1.00000000

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	0	0	.	.

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   70

ANALYSIS OF VARIANCE PROCEDURE

CLASS LEVEL INFORMATION

CLASS	LEVELS	VALUES
GROUP	4	1 2 3 4

NUMBER OF OBSERVATIONS IN DATA SET = 48

GROUP	OBS	DEPENDENT VARIABLES
0	0	O6T6 O6T7 O6T8 O6T9 O6T10 O6T11 O6T12 O6T13 O6T14 O6T15 O6T16 O6T17 O6T18
1	48	O6T1 O6T2 O6T3 O6T4
2	13	O6T5

NOTE: VARIABLES IN EACH GROUP ARE CONSISTENT WITH RESPECT TO THE PRESENCE OR ABSENCE OF MISSING VALUES.

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   71

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O6T1

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C. V.
MODEL	3	2902.16666667	967.38888889	3.36	0.0271	0.186303	22.5055
ERROR	44	12675.50000000	288.07954545		STD DEV		O6T1 MEAN
CORRECTED TOTAL	47	15577.66666667			16.97290622		75.41666667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	2902.16666667	3.36	0.0271

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   72

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O6T2

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C. V.
MODEL	3	1142.66666667	380.88888889	1.17	0.3321	0.073865	39.5863
ERROR	44	14327.00000000	325.61363636		STD DEV		O6T2 MEAN
CORRECTED TOTAL	47	15469.66666667			18.04476756		45.58333333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	1142.66666667	1.17	0.3321

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   73

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O6T3

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	773.56250000	257.85416667	1.26	0.3003	0.079020	86.2108
ERROR	44	9015.91666667	204.90719697		STD DEV		O6T3 MEAN
CORRECTED TOTAL	47	9789.47916667			14.31457987		16.60416667

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	773.56250000	1.26	0.3003

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   74

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O6T4

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	266.39583333	88.79861111	0.89	0.4517	0.057463	65.7962
ERROR	44	4369.58333333	99.30871212		STD DEV		O6T4 MEAN
CORRECTED TOTAL	47	4635.97916667			9.96537566		15.14583333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	266.39583333	0.89	0.4517

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   18:06 TUESDAY, NOVEMBER 4, 1980   75

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: O6T5

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	1.87692308	0.62564103	4.69	0.0308	0.610000	26.3718
ERROR	9	1.20000000	0.13333333		STD DEV		O6T5 MEAN
CORRECTED TOTAL	12	3.07692308			0.36514837		1.38461538

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GROUP	3	1.87692308	4.69	0.0308

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VITA

Mark Stephen Ostoich was born September 25, 1950, in Joliet, Illinois. He holds the Bachelor of Music and Master of Music degrees from Louisiana State University. He is presently Assistant Professor of Music at the University of Florida, Gainesville, Florida. He is a member of the applied music and musicology faculties of the Department of Music and performs with the Florida Woodwind Quintet and the Florida Baroque Ensemble. He also holds the position of principal oboe in the Jacksonville Symphony Orchestra and is active as a soloist and clinician in the state of Florida.

EXAMINATION AND THESIS REPORT

Candidate: Mark S. Ostoich

Major Field: Performance - Oboe

Title of Thesis: The Influence of Gouge and Shape on Pitch and Tone Quality of the Oboe

Approved:

E. Earnest Harrison

Major Professor and Chairman

James G. Traynham

Dean of the Graduate School

EXAMINING COMMITTEE:

William McKenzie

Robert Shambaugh

Paul Louis Abel

John P. Patterson

Paul Dirksmeyer

Date of Examination:

Dec. 1, 1980