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# TECHNICAL REVIEW

No. 2 – 1967

# Contents



K. LARSEN & SØN - LYNGBY

# Mechanical Failure Forecast by Vibration Analysis

By

*J. J. Hvillum*

## ABSTRACT

The article describes various methods of mechanical failure forecasting by means of vibration measurement and analysis. Starting with a brief discussion of the importance of obtaining a measure for the growth in mechanical wear of production machinery, different vibration analysis methods which may be used to obtain such a measure are outlined. It is shown that an analysis in the form of a frequency spectrum of the vibrations at various points on some machinery, the analysis being performed at regular time intervals, can give a good indication of the wear.

Finally, two examples are given of factories which utilize the described principles and where the number of breakdowns has been reduced considerably since the methods of failure forecasting were introduced. It is estimated that the increase in production obtained in this manner has paid for the measuring equipment in less than six months.

## SOMMAIRE

L'article décrit diverses méthodes de prévision des défauts mécaniques basées sur l'étude et l'analyse des vibrations. Partant d'une brêve discussion de l'importance que revêt l'obtention d'une mesure de l'accroissement de l'usure mécanique des machines de production, différentes méthodes sont esquissées d'analyse des vibrations auxquelles on peut recourir pour obtenir une telle indication. On montre qu'une analyse des vibrations en divers points d'une machine, effectuée à intervalles de temps réguliers sous la forme d'un spectre de fréquences, peut donner une bonne indication de l'usure.

Pour terminer, deux exemples sont fournis d'usines qui utilisent les principes décrits et où le nombre de pannes a été réduit considérablement depuis que des méthodes de prévision des difficultés ont été introduites. On estime que le gain en production obtenu de la sorte a remboursé l'équipement de contrôle en moins de six mois.

## ZUSAMMENFASSUNG

Verschiedene Methoden zur Vorhersage mechanischer Schäden mit den Mitteln der Schwingungsmessung und -Analyse werden beschrieben. Zu Beginn wird kurz diskutiert, wie wichtig es ist, sich ein Maß für die Stärke des mechanischen Verschleisses an Fertigungsmaschinen zu verschaffen. Dann werden verschiedene Methoden der Schwingungsanalyse umrissen, die sich zur Gewinnung eines solchen Maßes eignen. Es wird gezeigt, daß eine Analyse in Form von regelmäßig durchgeführten Frequenzanalysen der Schwingungen an verschiedenen Punkten bei vielen Maschinen gute Hinweise auf den Verschleiß liefern kann.

Schließlich werden als Beispiel zwei Fabriken angeführt, die nach den beschriebenen Grundsätzen verfahren, und wo die Ausfallrate beträchtlich gesunken ist, seitdem die Methoden der Fehlervorhersage eingeführt wurden. Es wird geschätzt, daß die auf diese Weise erzielte Produktionssteigerung die Kosten für die Meßausrüstung in weniger als sechs Monaten wieder eingebracht hat.

For a long time now it has been possible to keep a check on a man's physical condition by regular clinical tests. Similarly, the working condition of a combustion engine has been deduced from measurements of compression, temperature etc. Today however, modern electronic measuring techniques allow a continuous check on the state of operation of practically any sort of machinery by simple vibration measurements. The purpose of this article is to discuss the principles involved in such measurements, to indicate some suitable instrumentation systems, and to give some examples of results obtained with systems already in operation.

In order that the intended measurements be possible, one requirement must be fulfilled: The construction which is to be tested must contain sliding or rotating parts whose motion is approximately periodic. As a result of the restricted movement of these parts, alternating forces will be generated which have to be counterbalanced by forces in the stationary parts restricting the motion. The presence of these exciting forces results in undesirable mechanical vibrations in the structure. These vibrations will find their way to the neighbouring mechanical parts and diminish in amplitude with distance from their source.*)

Any mechanical machine will usually possess several sources of vibration, resulting from different moving systems, and the vibrations produced will be characteristic of their individual sources, with respect to their frequency, amplitude and phase. Particular frequency components are often traceable to some moving element's frequency of repetition or some of its harmonics, whereas the absolute amplitude of the vibration is consistently unpredictable. This quantity is determined by a variety of factors, one of which is the mechanical stability of the moving system. The method of predicting mechanical failure described in this article utilizes the fact that mechanical instability increases with time as a consequence of unbalance caused by wear, insufficient lubrication and inadequate maintenance. Suitable vibration measuring equipment must therefore be able to identify and separate frequency components and to indicate changes in amplitude with time.

Under what circumstances it is worth while to utilize this form of inspection as a tool to avoid unplanned production stand-stills, must be left to individual judgement, but since unnecessary and costly gaps in an otherwise continuous production process can be prevented by simple monitoring of vibration, the method is often justified. Total production stand-stills are frequently caused by defects in small mechanical parts, such as gear wheels or bearings. These defects would have been discovered by routine inspections and could have been corrected at a planned maintenance period. As the trend in mechanical

*) Due to mechanical resonances no simple mathematical relationship governs the transmission of vibrations through various parts of a practical structure. The above statement of diminishing amplitudes therefore neglects resonance effects which very often complicate the situation considerably.

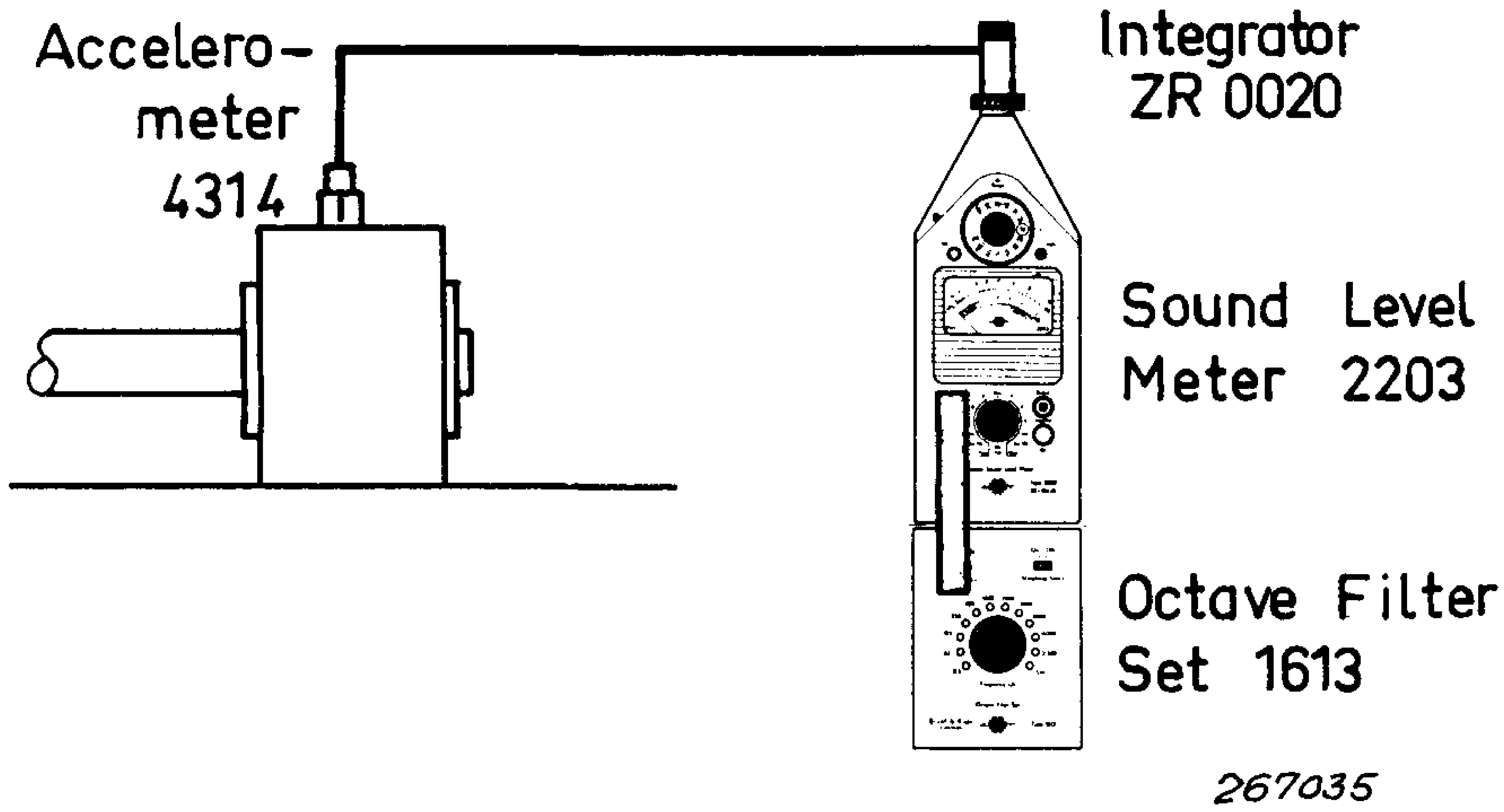



*Fig. 1. Simple instrumentation system for measurement and analysis of vibration.*

design is to utilize the various components and materials to their utmost capability, strong arguments are in favour of an effective maintenance policy. Some examples of instrumentation systems suitable for monitoring of vibration in mechanical systems are indicated in the following text. The requirements already mentioned are met by the relatively simple combination shown in Fig. 1. It consists of

Accelerometer Type 4312–13–14–15
Integrator ZR 0020
Precision Sound Level Meter Type 2203
Octave Filter Set Type 1613

The accelerometer is placed at a well defined point on the mechanical construction where the characteristic vibrations to be indicated are found to exist with sufficient intensity. It has the required technical specifications with regard to frequency response, dynamic range and operating temperature range, to be able to convert the complex mechanical vibrations into an equivalent electrical signal, under most conditions met with in production machinery. The Sound Level Meter amplifies the signal from the accelerometer and the meter reading indicates the vibration level in units of acceleration ($m/sec^2$), velocity (m/sec) or displacement (m).

Velocity and displacement are obtained from the acceleration signal by electrical integration with the Integrator.

The Filter Set which connects mechanically and electrically to the Sound Level Meter is used for analysis of the vibration signal. It consists of eleven parallel octave filters covering the frequency range 22 Hz to 45ooo Hz as shown in Fig. 2. The filters are switched in successively and the meter then gives the vibration level in each octave band, with center frequencies as indicated by the selector switch. The readings obtained may be written in a

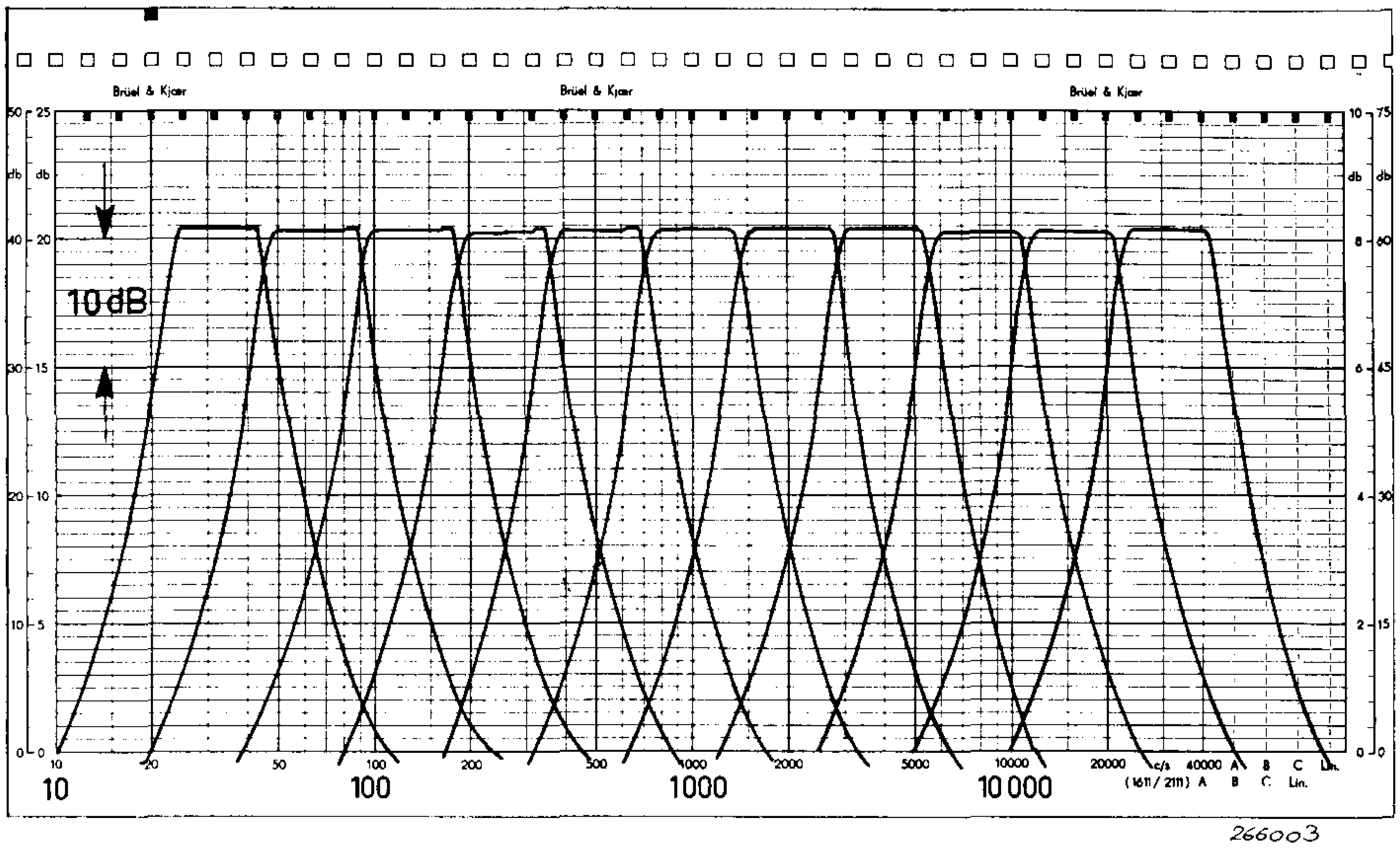



*Fig. 2. Response curves for the Octave Filter Set Type 1613.*

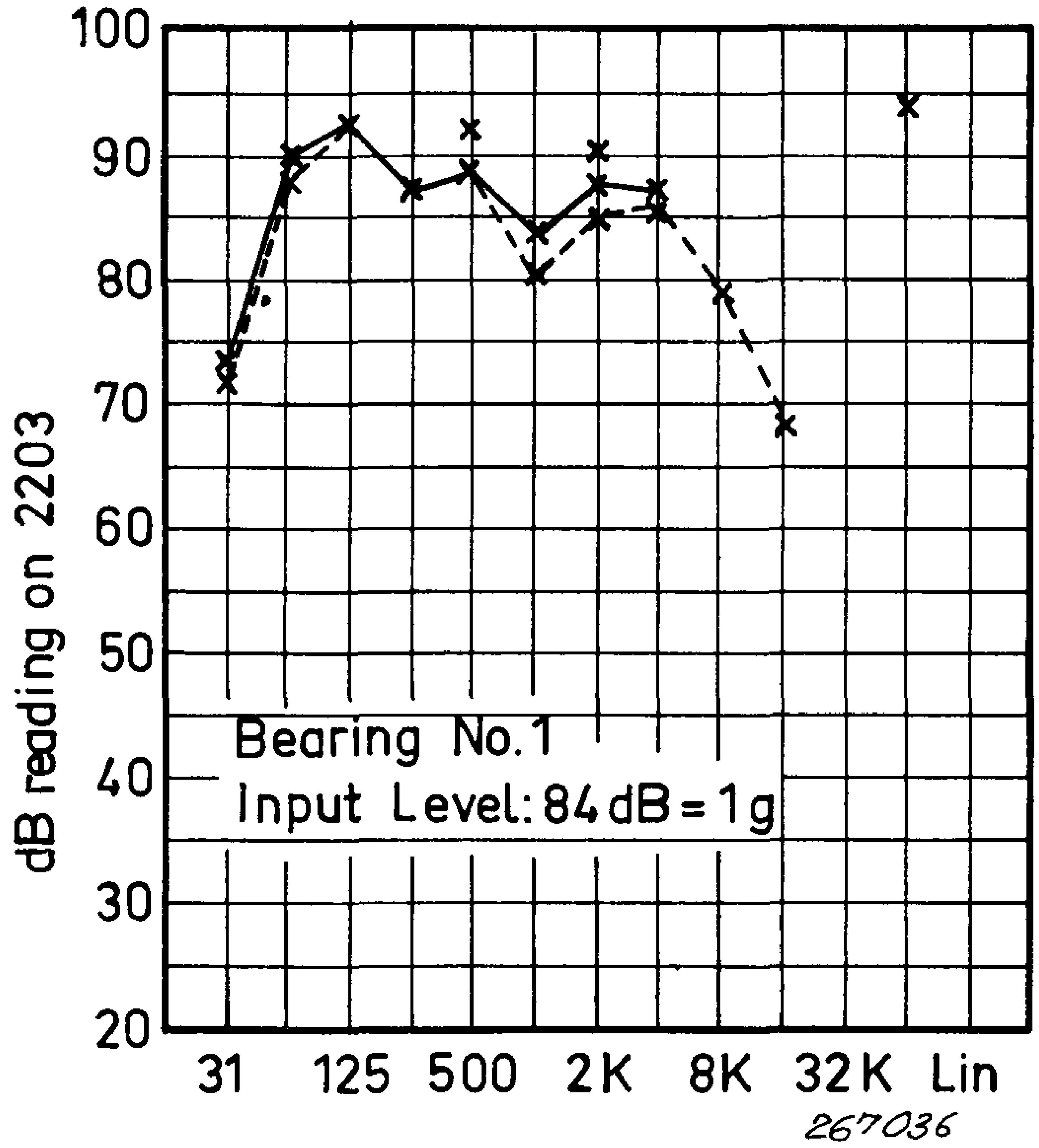



*Fig. 3. Octave spectrogram as plotted manually from readings obtained with the instrumentation shown in Fig. 1.*

table, or made into a curve as shown in Fig. 3. This is called an octave spectrogram. When spectrograms obtained at regular intervals are compared, any changes in vibration level in the various frequency bands will show up clearly. These changes will soon supply the experienced maintenance personnel with sufficient information to decide when the machinery is due for repair or parts are to be replaced.

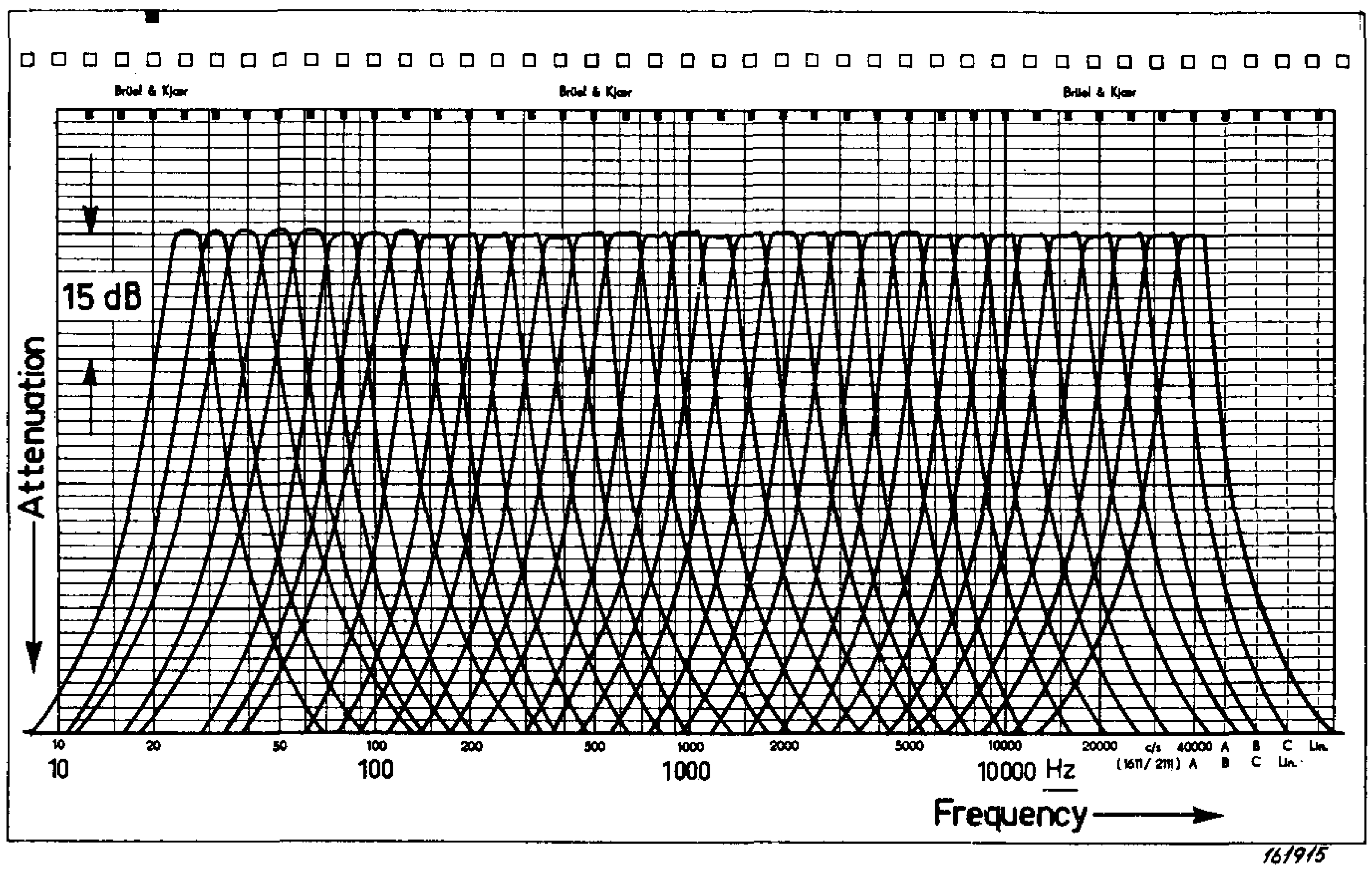



*Fig. 4. Response curves for a set of 1/3 octave filters (Type 1612).*

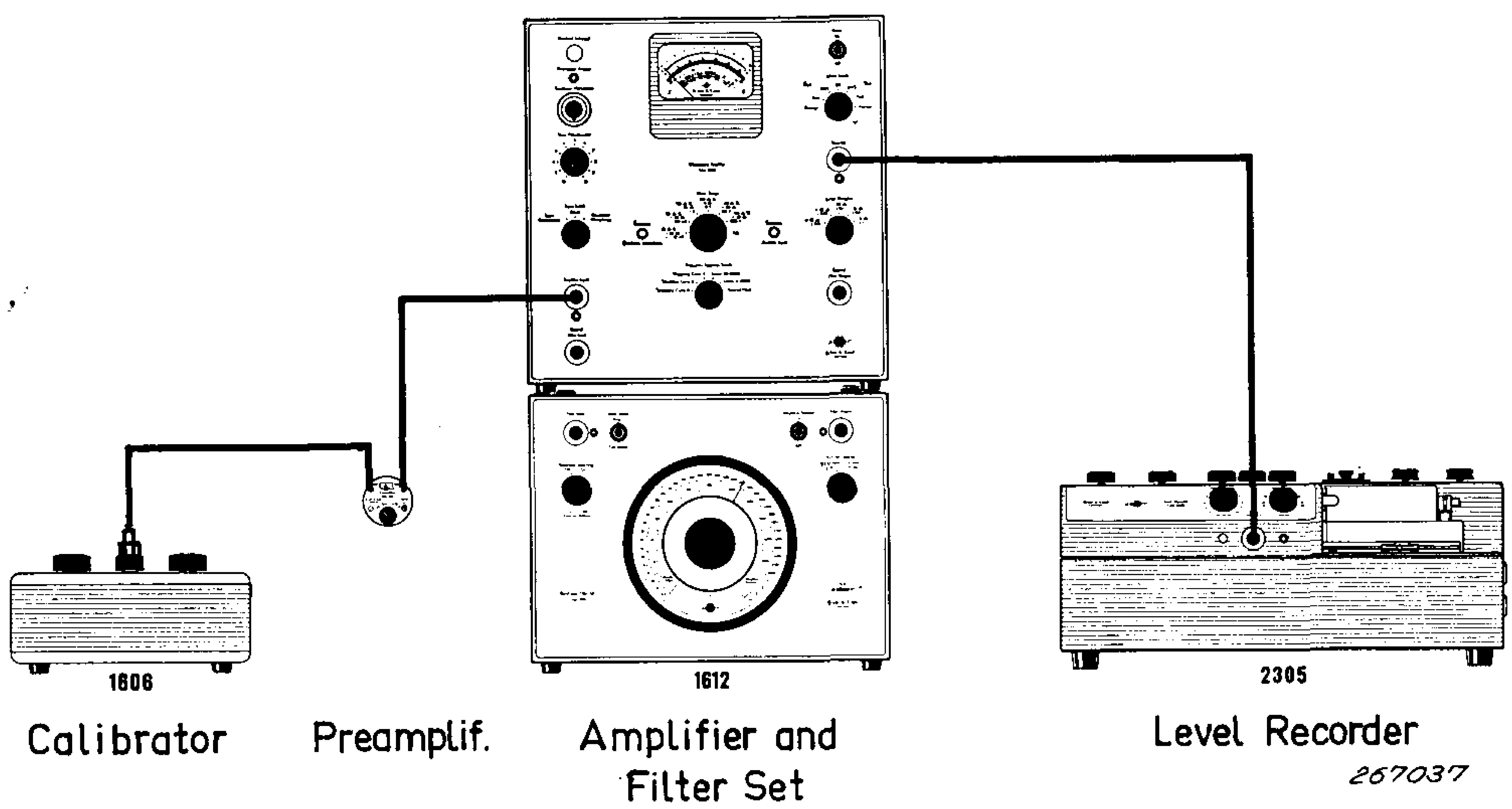



*Fig. 5. More advanced system with automatic recording of octave or 1/3 octave spectrograms.*

The system described above assumes that an octave analysis of the vibration signal is sufficient. Should a more detailed analysis be required the Filter Set Type 1612 can be employed instead of Type 1613. This makes 1/3 octave analysis possible, as indicated by Fig. 4, with three times as many selective filters available for characterization of the vibration.

The Filter Set Type 1612 is also part of the more advanced system shown in Fig. 5. Additionally this system consists of

Calibrator Type 1606
Preamplifier Type 2616 (2623)
Amplifier Type 2603
Level Recorder Type 2305

The principles of operation are not different from those described above, but the analysis is done automatically, giving more convenient and accurate results. The calibrator employs a small shaker table which is set to vibrate at the mains frequency with an acceleration of 1 g peak (~ 10 m/sec$^2$ peak). With the accelerometer mounted on the shaker table a well defined reference signal is obtained, which is used for calibration of the whole measuring system.

An accidental erroneous positioning of control switches, perhaps contributed by unauthorized personnel, will likewise be easily disclosed.

In addition the calibrator contains the necessary accelerometer input stage and integrating circuits for measurement of velocity or displacement as well as acceleration. To obtain greater flexibility a separate acelerometer preamplifier is employed. This is an impedance transformer (Type 2616 or 2623), which transforms the high impedance accelerometer signal into a low impedance signal, which may then be transmitted up to several hundred meters via ordinary two-core cables. It is then possible to operate with the analyzing equipment in a permanent position, and with only the accelerometer and preamplifier to be carried around the measuring site.

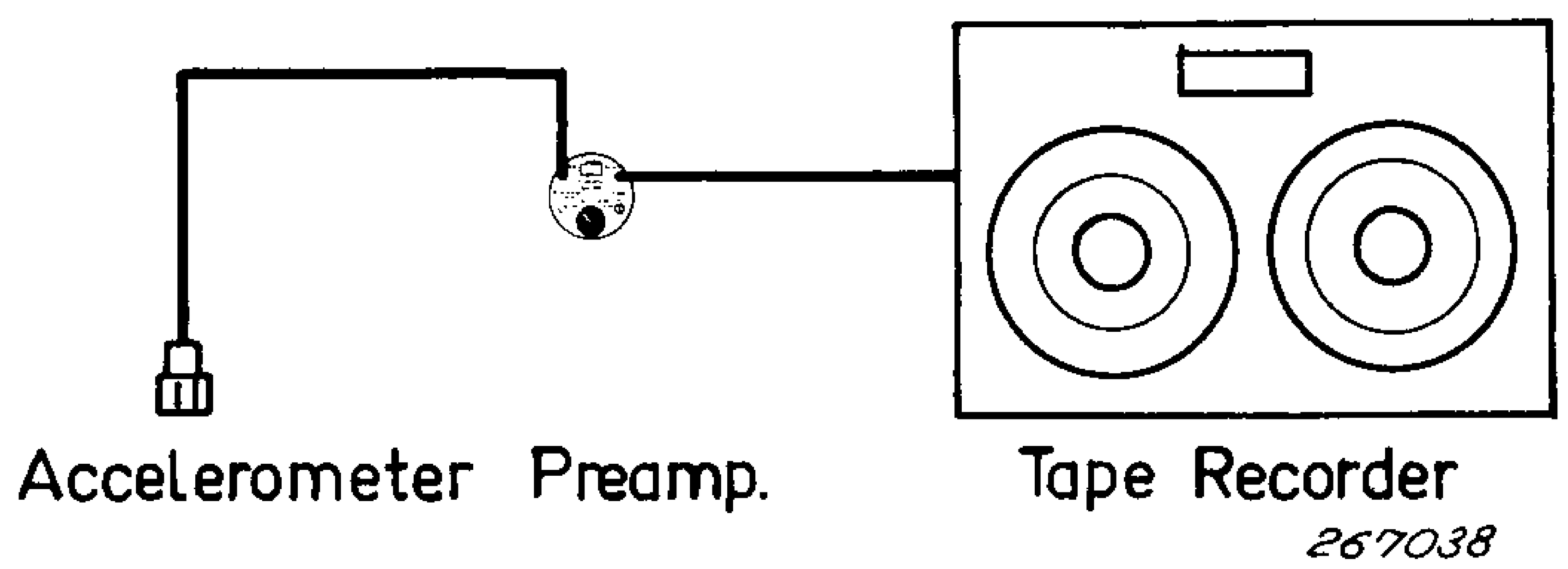



*Fig. 6. Collection of vibration data using a portable tape recorder.*

If circumstances to dot permit a direct cable connection between the measurement site and the analyzing equipment, e.g. because of a missing mains supply or a too wide spacing of the measuring points, the solution shown in Fig. 6 may be found suitable.

This utilizes a portable tape recorder for collection of the vibration data from the accelerometers. Later the tape is played back with the tape recorder output connected to the analyzing equipment, and analysis and recording is carried out in exactly the same way as before. In order to determine the absolute level of the vibration signal a known reference signal is required. The reference is obtained with the accelerometer mounted on the calibrator and the 1 g peak signal is recorded on the tape before the measurements are made. The function of the tape recorder is to replace the direct transmission of data, and without the reference signal, the tape recorder quality requirements would be too stringent. A critical examination of the actual vibration signal to be recorded, especially with regard to frequency contents and dynamic range, will in most cases show that a good commercial tape recorder is able to do the job, provided that a reference signal is employed.

In Fig. 5 was shown a Level Recorder Type 2305 connected to the analyzing instrument. Instead of the previous manual recording of the measuring results, the Level Recorder presents the spectrograms automatically on preprinted, frequency calibrated paper. The advantages of this method are obvious, in addition to a quicker and more rational recording of the vibration data, the comparison of results, which is the main idea behind this method of inspection, is made much more accurate. As well as eliminating the human measurement errors, the automatic spectrogram shows the important variations in level which make an exact meter reading impossible and which are often omitted in manual recording. Typical spectrograms as obtained with the Level Recorder are shown in Fig. 7.

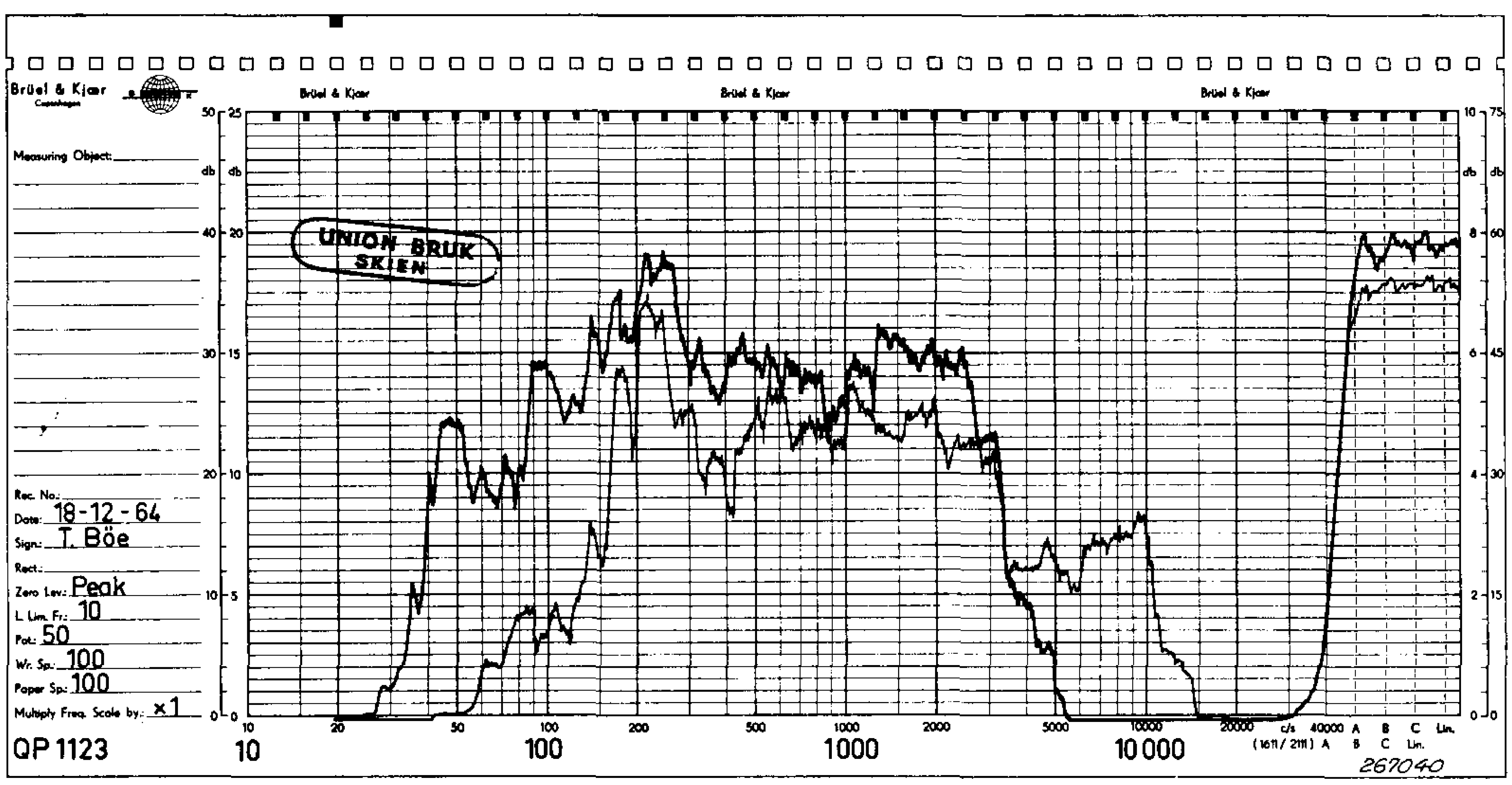



*Fig. 7. Typical spectrograms obtained at two different times, showing increase in vibration level at certain frequencies.*

After careful identification the spectrograms are filed and ready for comparison with new recordings at any later time. The comparison can either be carried out by individual inspection of the spectrograms, or by recording several times on the same paper charts, running the paper back and carrying out the measurements again in the same sequence. The writing pen of the Level Recorder will follow the old spectrograms and any change in vibration level will show up very distinctly. As the maintenance personnel gains more experience in interpreting the spectrograms, this method will soon be found valuable as a check on mechanical soundness of production machinery.

With time it will also be possible to predetermine the typical frequencies and amplitude limits that are going to prove especially critical. A further knowledge of the vibrational behaviour might result in a more continuous and efficient production, if some part of the machinery is monitored all the time.

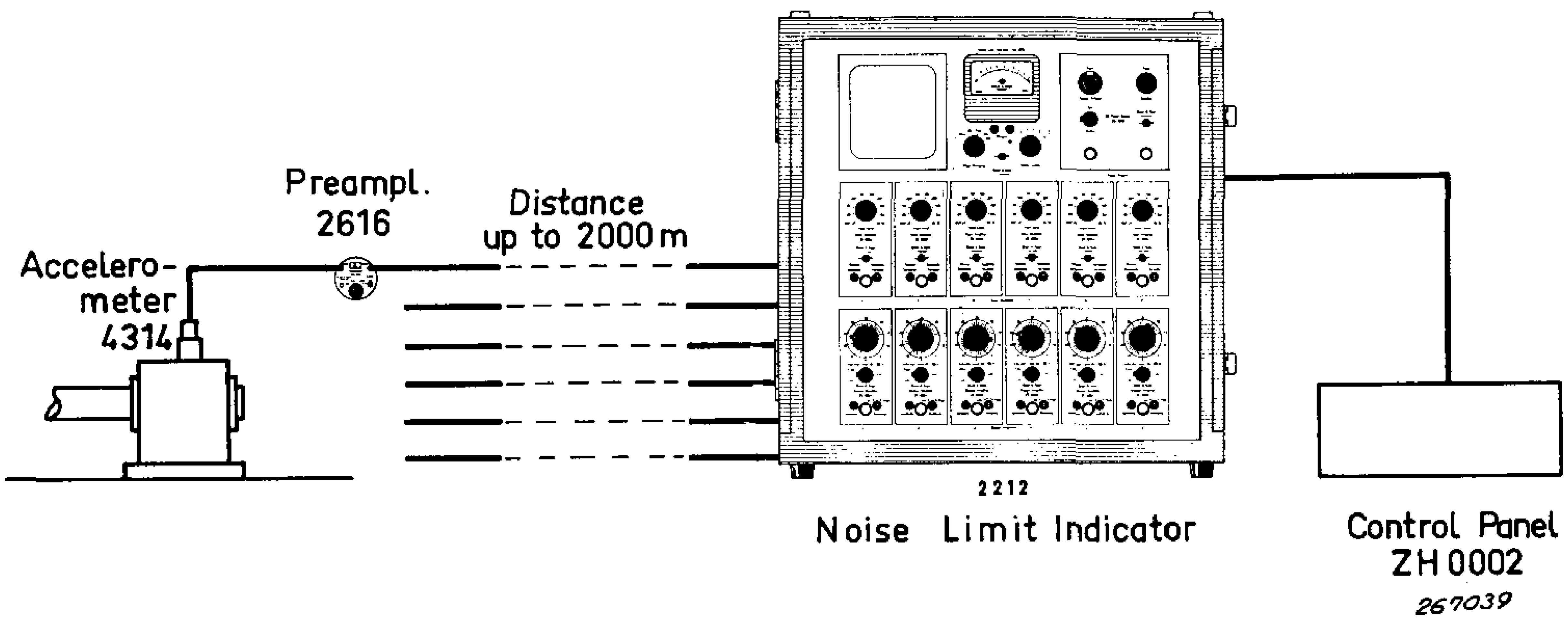
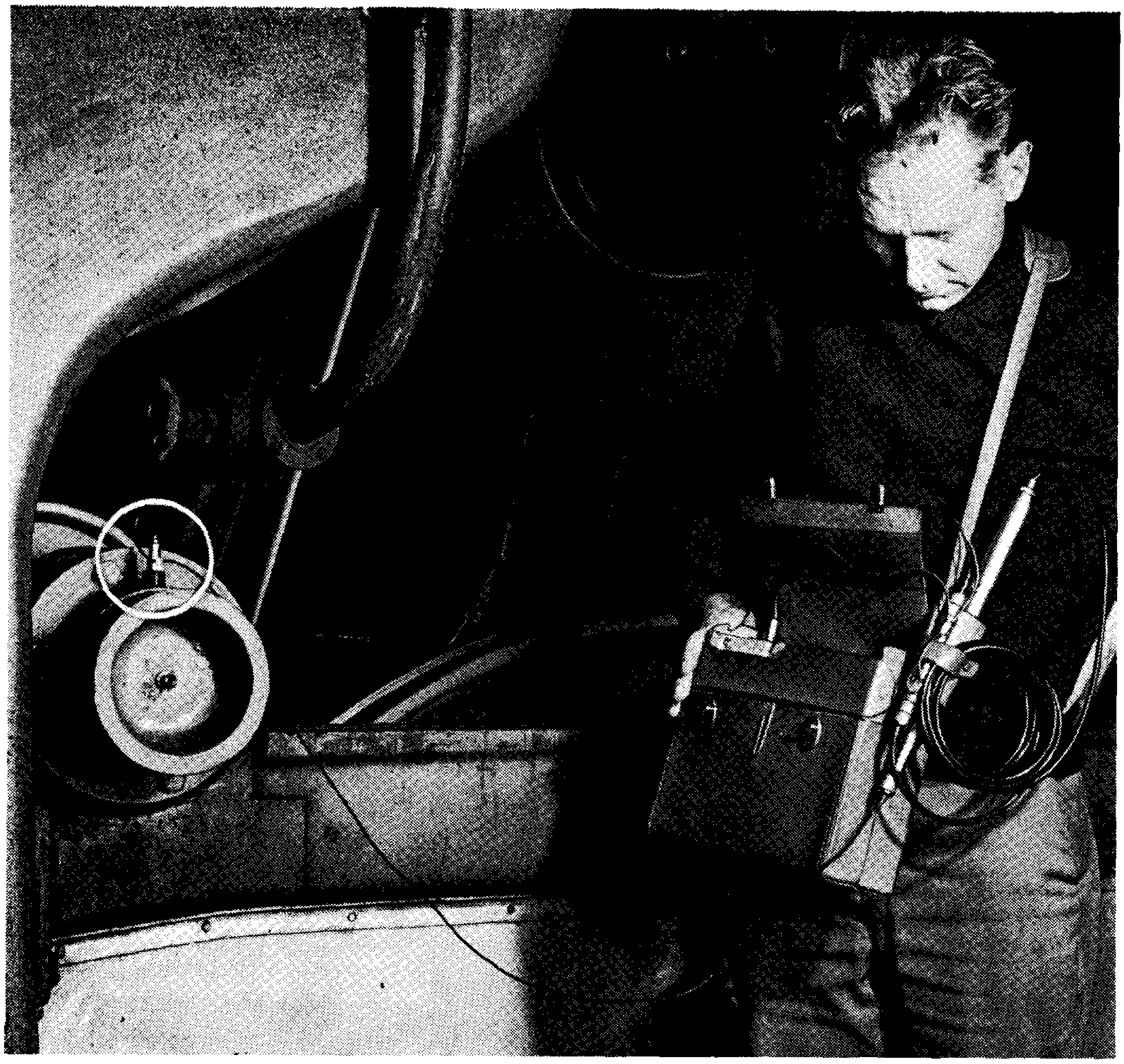



*Fig. 8. System for continuous monitoring of vibration level at six measuring points.*

The system shown in Fig. 8 gives the possibility of keeping a continuous check on the vibration at six measuring positions. The Noise Limit Indicator Type 2212 contains six parallel amplifiers, which are provided with the most suitable octave or 1/3 octave filter, corresponding to the typical frequency component of the vibration signal at each point. The vibration limit is set on an attenuator for each channel. Should the vibration level at any of the six points exceed the preset limit, a visual alarm (red lamp) is activated, or alternatively an acoustic alarm may be connected. The maintenance crew is thus alerted, being able to assess the situation and act accordingly.

In order to furnish some results obtained from application of these principles, we take as examples Dalen Portland Cement and Union Bruk, Norway. These firms were, as far as we know, among the first to decide on the method of vibration analysis as a control on production machinery. Excellent results have been obtained, and their maintenance personnel are convinced that the number of breakdowns has been reduced considerably since the installation of the vibration equipment, and repairs and replacements of small parts, such as bearings and gear wheels, are now undertaken during the regular maintenance periods. Furthermore they estimate that the resulting increase in production has paid for the measuring equipment in less than six months. The photographs in Fig. 9 show the maintenance engineer in action, storing vibration data on a tape recorder, and also a permanent instrumentation system. Because of the complicated nature of the machinery and the environmental conditions, it was found most convenient to use the tape recorder as a data transmission link, and to place the analyzing equipment at a more central position.

Finally the last two pictures document the results from the vibration analysis. A replaced bearing is shown and part of the store for replaced parts.



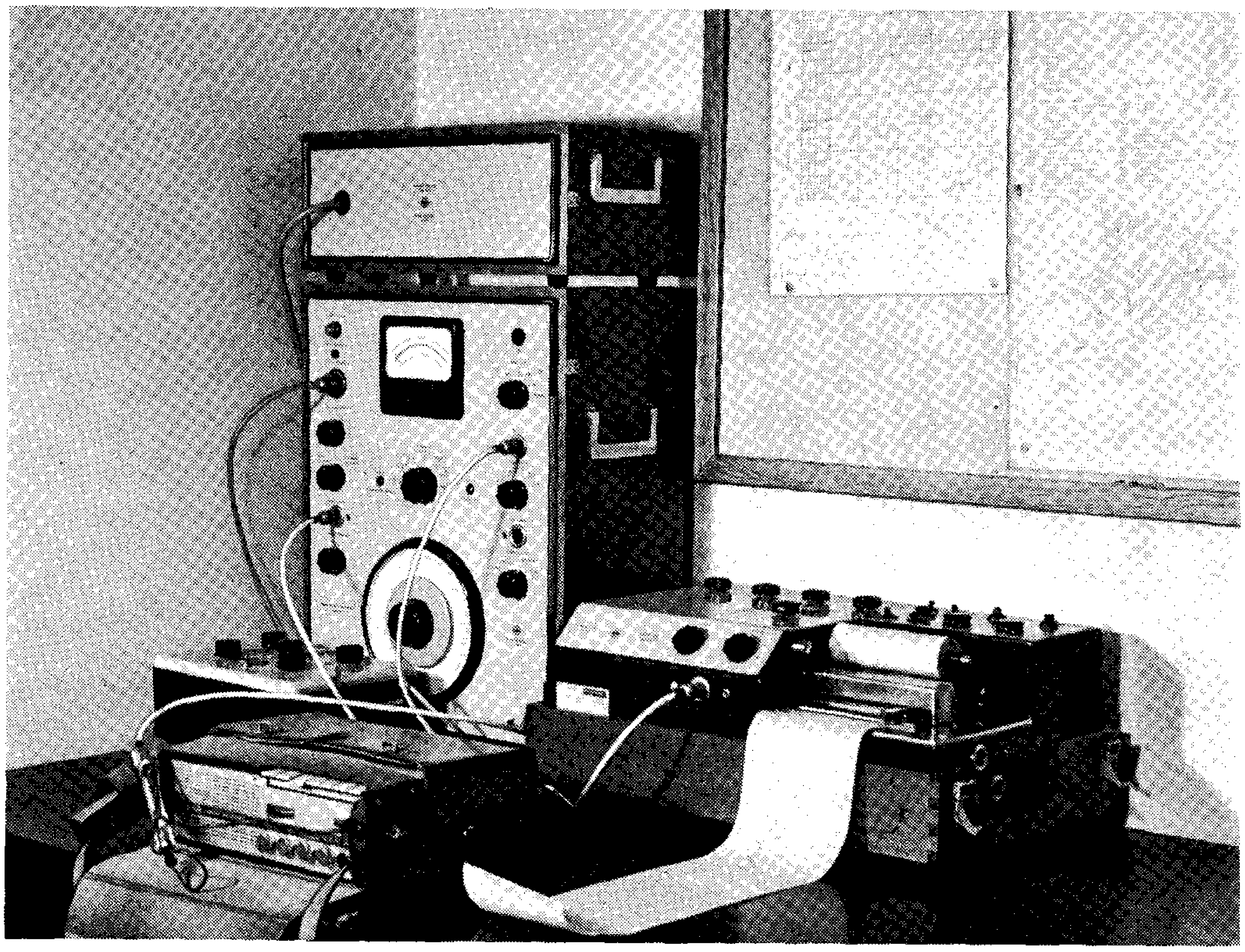


*Fig. 9a. Maintenance engineer in action with tape recorder.*
*b. Permanent instrumentation system for vibration analysis.*

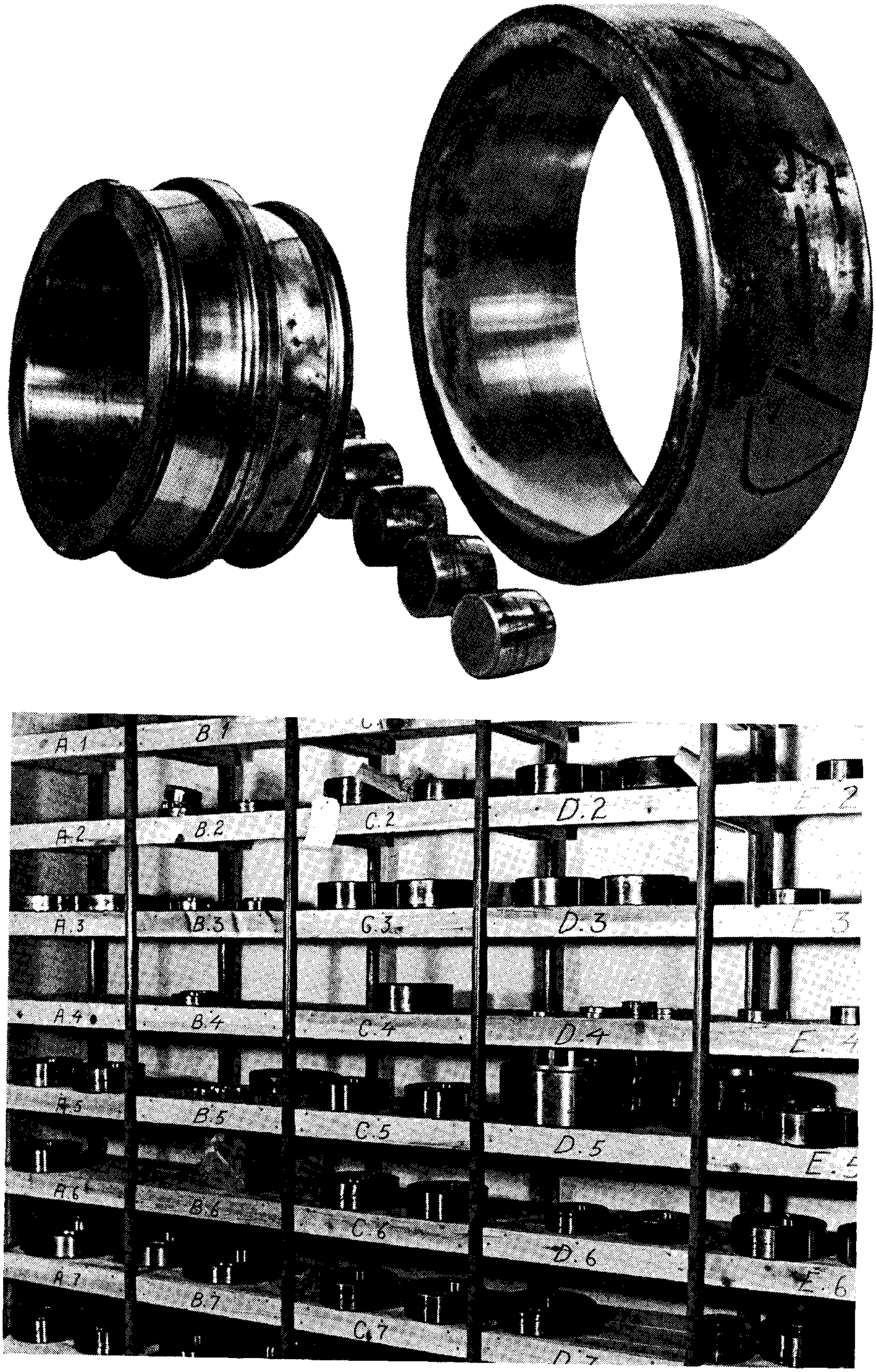



*Fig. 10. Mechanical parts replaced after vibration analysis.*

# Tapping Machines for Measuring Impact Sound Transmission

By

*Per V. Brüel,* D.Sc.

**ABSTRACT**

An investigation has been made on the influence of the supporting leg configuration of the Tapping Machine Type 3204 upon the measuring result. The experiments confirmed the findings of Dr. G. Venzke et.al. of the German Physikalische Technische Bundesanstalt regarding the influence of the material used in the contact points between the legs and the floor. However, it was also found that the distance between the hammers and the leg contact points, to a certain extent, influenced the measurements. As a consequence of these investigations the positioning of the supporting legs have been made adjustable, facilitating both measuring accuracy and ease of transportation of the machine. Also the material used in the contact points of the legs has been changed from brass to a specially designed synthetic rubber.

**SOMMAIRE**

Une étude a été faite de l'influence qu'a sur les résultats des mesures la configuration des pieds qui supporten la Machine à Frapper type 3204. Les expériences ont confirmé les découvertes du Dr. G. Venzke du Physikalische Technische Bundesanstalt allemand concernant l'influence du matériau utilisé pour réaliser le contact entre les pieds et le plancher. Il a cependant également été trouvé que la distance entre les marteaux et les points de contact des pieds exerçait une certaine influence sur les mesures. Conséquence de ces recherches, le positionnement de ces pieds a été rendu ajustable, améliorant ainsi la précision de la mesure et la facilité de transport de la machine. De même le matériau utilisé pour les points de contact des pieds a été changé, passant du laiton à un caoutchouc synthétique étudié spécialement en vue de cette application.

**ZUSAMMENFASSUNG**

Am Normhammerwerk Typ 3204 wurde untersucht, welchen Einfluß auf das Meßergebnis die Anordnung der Standfüße besitzt. Die Versuche erhärteten die Ergebnisse von G. Venzke und anderen (Physikalisch-Technische Bundesanstalt, Braunschweig) über den Einfluß des Materials, mit dem die Füße den Boden berühren. Darüberhinaus fand man, daß die Abstände zwischen den Hämmern und den Fußberührungspunkten in einem gewissen Ausmaß die Messungen beeinflussen. Als Folgerung aus diesen Untersuchungen wurden die Füße des Normhammerwerks schwenkbar gestaltet, wodurch sowohl die Genauigkeit der Messungen als auch ein leichter Transport des Gerätes gewährleistet sind. Auch wurden die Füße mit einer Sohle aus speziellem synthetischen Kautschuk an Stelle von Messing versehen.

Measurements of impact sound transmission made both scientifically and commercially, are today almost always made in accordance with ISO Recommendation R140[1], which states that a Tapping Machine should be used to produce the standardized impact on the floor to be tested. Section 5.1 of the Recommendation specifies the characteristics of the Tapping Machine as follows:

> "It should have five hammers placed in a line, the distance between the two end hammers being about 40 cm.
> The time between successive impacts should be 100 ± 5 milliseconds.

The effective mass of each hammer should be 0.5 kg (within ± 2.5 per cent).
The drop of a hammer on a flat floor should be equivalent to a free drop without friction of 4 cm (within ± 2.5 per cent).
The part of the hammer which strikes the floor should be a cylinder of brass or steel, 3 cm in diameter, with a spherical end having a radius of about 50 cm.
In the case of a fragile floor covering, hammers should be used having the part that strikes the floor coated with a layer of rubber, of which the dimensions, composition and vulcanization are specified.
The hammer should strike the floor only once each time it is released and should always fall through an effective height of 4 cm."

It can be seen from the above that no specification is given for the way in which the Tapping Machine should be supported. In other words, it is left to the manufacturer to decide on both the construction and placing of the necessary support legs. Brüel & Kjær have designed their Tapping Machine Type 3204 in accordance with ISO R140, while at the same time trying to achieve lightness and portability.[2] Due to the consideration for portability, the

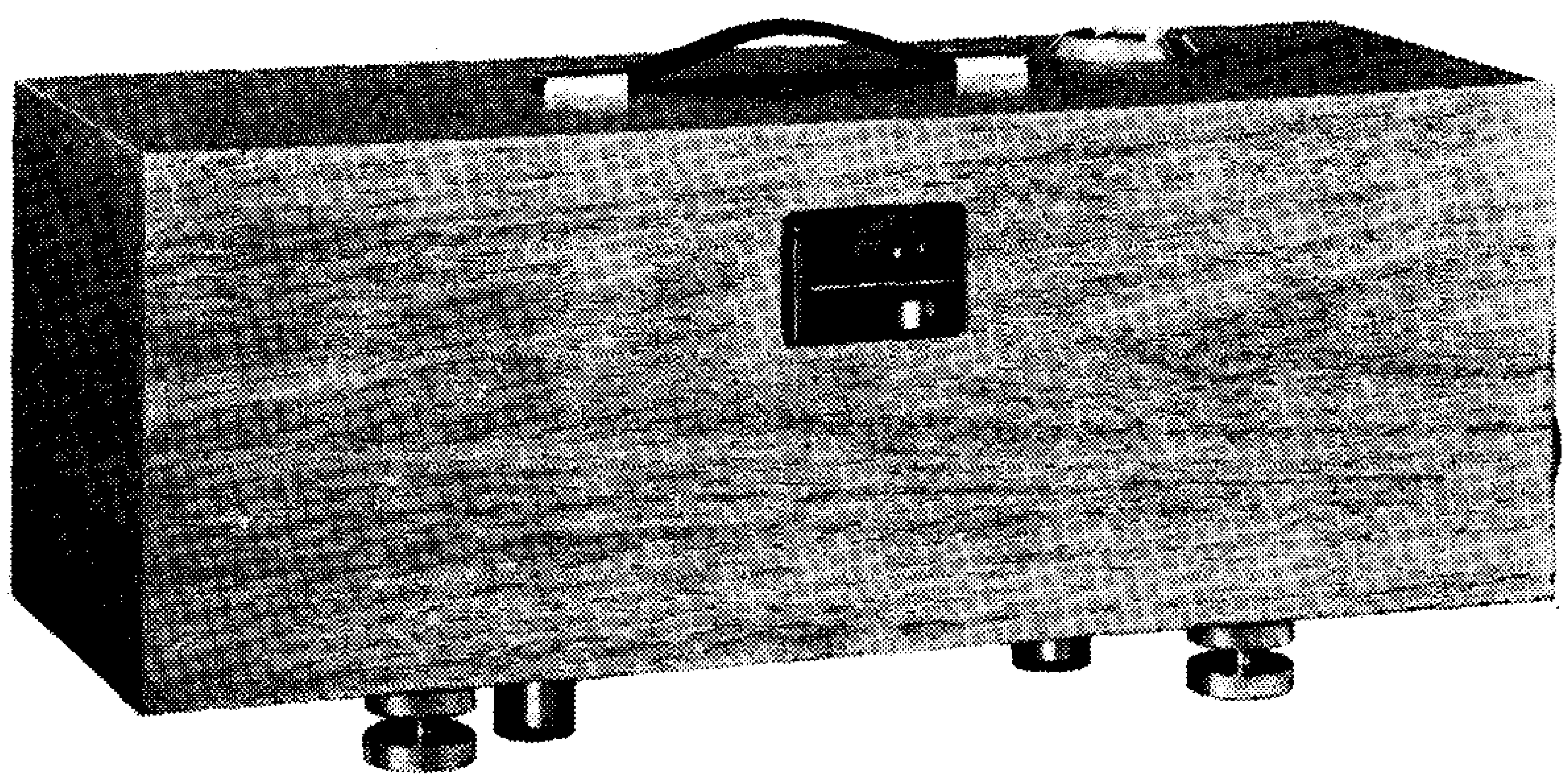


*Fig. 1. Brüel & Kjær Tapping Machine Type 3204.*
*Dimensions: 20 × 55 × 20 cm. Weight: 16 kg.*

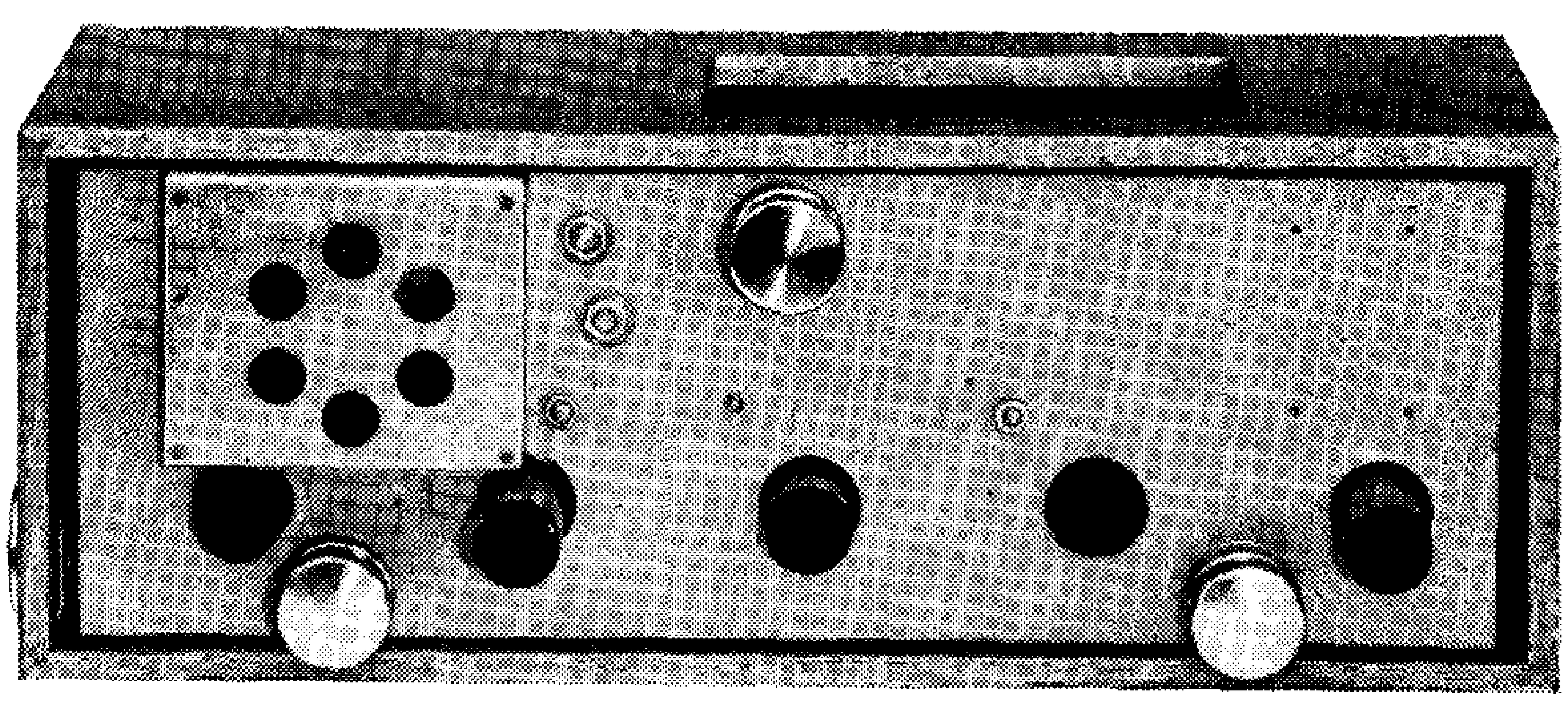


*Fig. 2. View of the underside of the Tapping Machine Type 3204 showing the five hammers and the three supporting legs.*

machine is of narrow design, consequently the three supporting legs are placed very close to the hammers as can be seen in figures 1 and 2.

Some time ago, a very careful investigation made by Dr. G. Venzke, et. al. of Physikalisch-Technischen Bundesanstalt[3] (the German National Physical Laboratory), showed that the measuring results at lower frequencies depends, to some extent, upon the placing of the supporting legs, as well as the material used at the contact points between the legs and the floor, e. g. legs made entirely of metal or covered with soft rubber.

The experiments carried out at PTB were made on a solid reinforced concrete slab covered with a type of glass wool over which a very light floor was placed. This construction has a very good impact sound insulation. However, the very light floor will reach a considerable amplitude during the measurements, and consequently the vibration amplitudes in connection with the small vibrating mass will be influenced by the contact from the supporting legs of the Tapping Machine. This gives some variation in the vibration picture, especially with this type of floor construction. The PTB measurements were made with three different Tapping Machines, i.e.

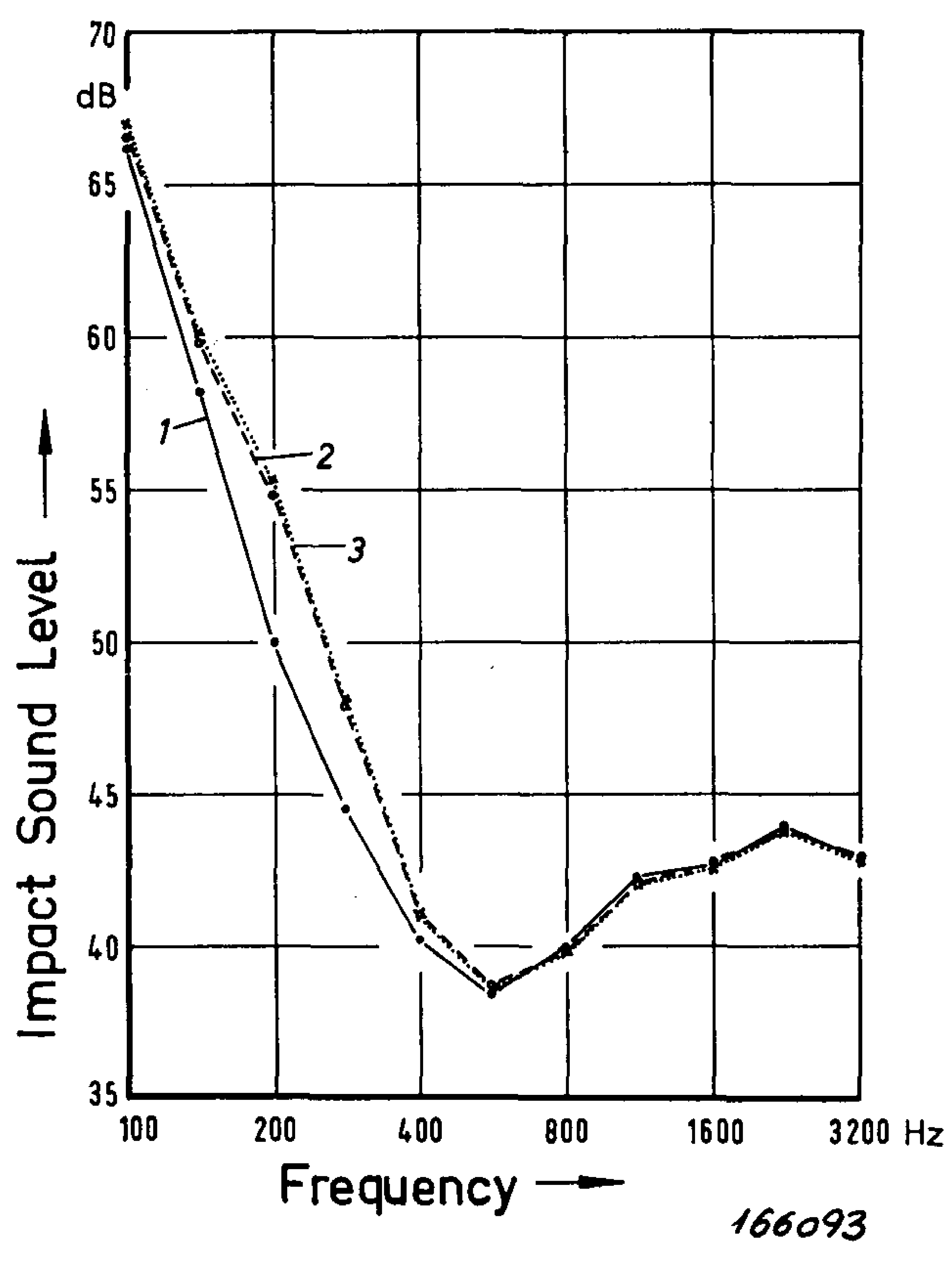



*Fig. 3. The measuring results from PTB made on a floating floor 2 × 2.4 m².*
*Curve 1 – normal metal feet,*
*Curve 2 – rubber feet,*
*Curve 3 – sponge rubber feet.*

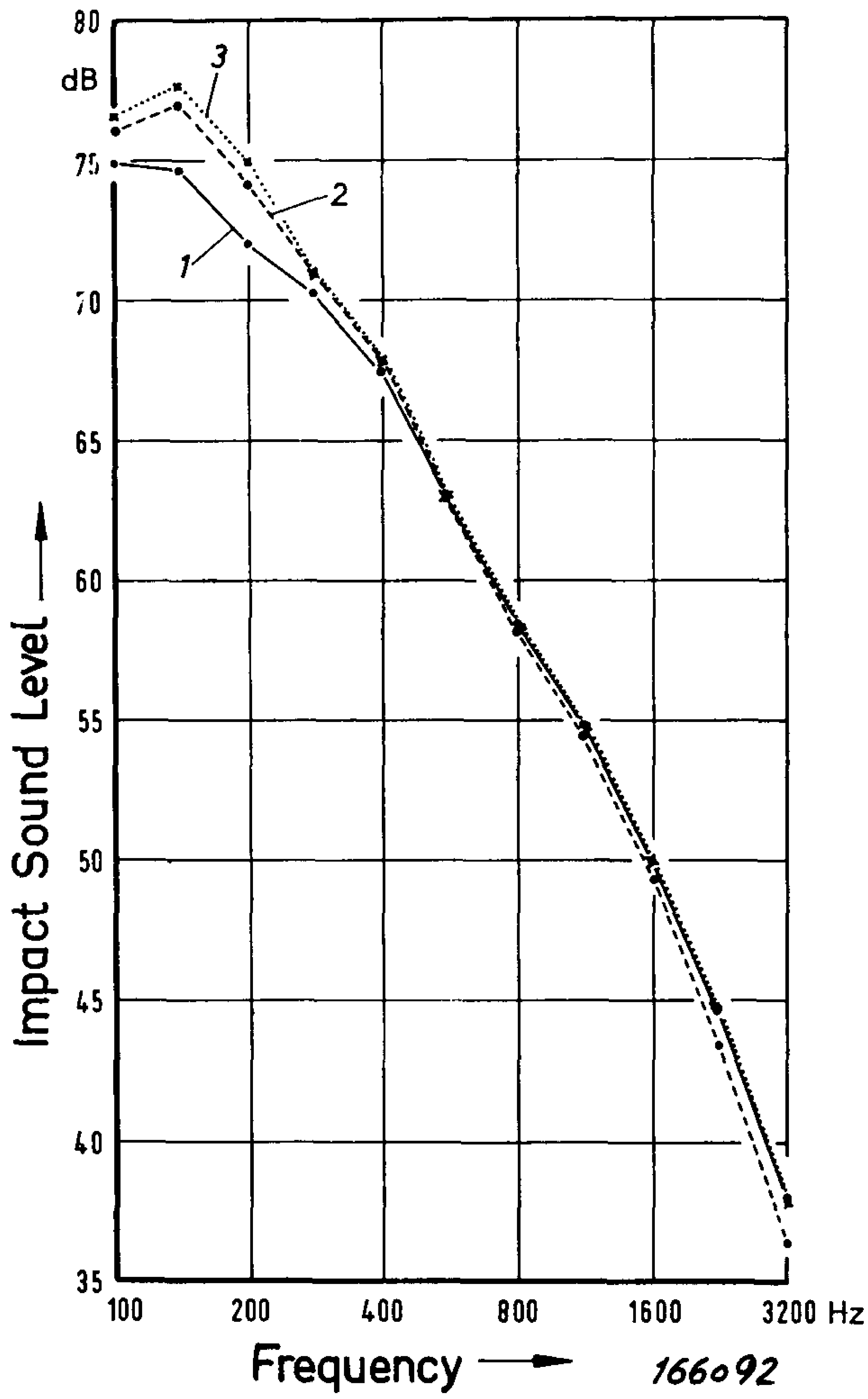



*Fig. 4. Same as Fig. 3, but where the floor is covered with linoleum.*

a. with supporting legs of solid metal,
b. with supporting legs capped with rather hard rubber.
c. with supporting legs capped with sponge rubber.

The results of the measurements made on the floor construction as described but with and without linoleum are shown in Figs. 3 and 4.

From the curves it can be seen that at the lower frequencies in both measurements the results obtained with the solid metal legs are different from those obtained where the Tapping Machine is more softly supported. This indicates that an undesired interaction exists between the metal legs and the light layer of the floor. It is also seen from Fig. 4 that if the floor is covered with thin linoleum, this interaction is reduced and takes place only at the lower frequencies. It is also seen from these measurements that there is very little difference between the results obtained with hard rubber and sponge rubber feet.

As it is extremely undesirable that a standardized Tapping Machine used on special floor constructions can give different results depending on the way that it is supported, Brüel & Kjær decided to make further investigations on this point and modify the design of the machine accordingly. The German measurements indicated that it should be sufficient to fit rubber feet to the legs of the present machine.

Brüel & Kjær tried to repeat the German results with a special Tapping Machine where the supporting legs could not only be replaced with feet of different material but they could also be placed at variable distances from the hammers by means of a simple slot arrangement. This machine is shown in Fig. 5.

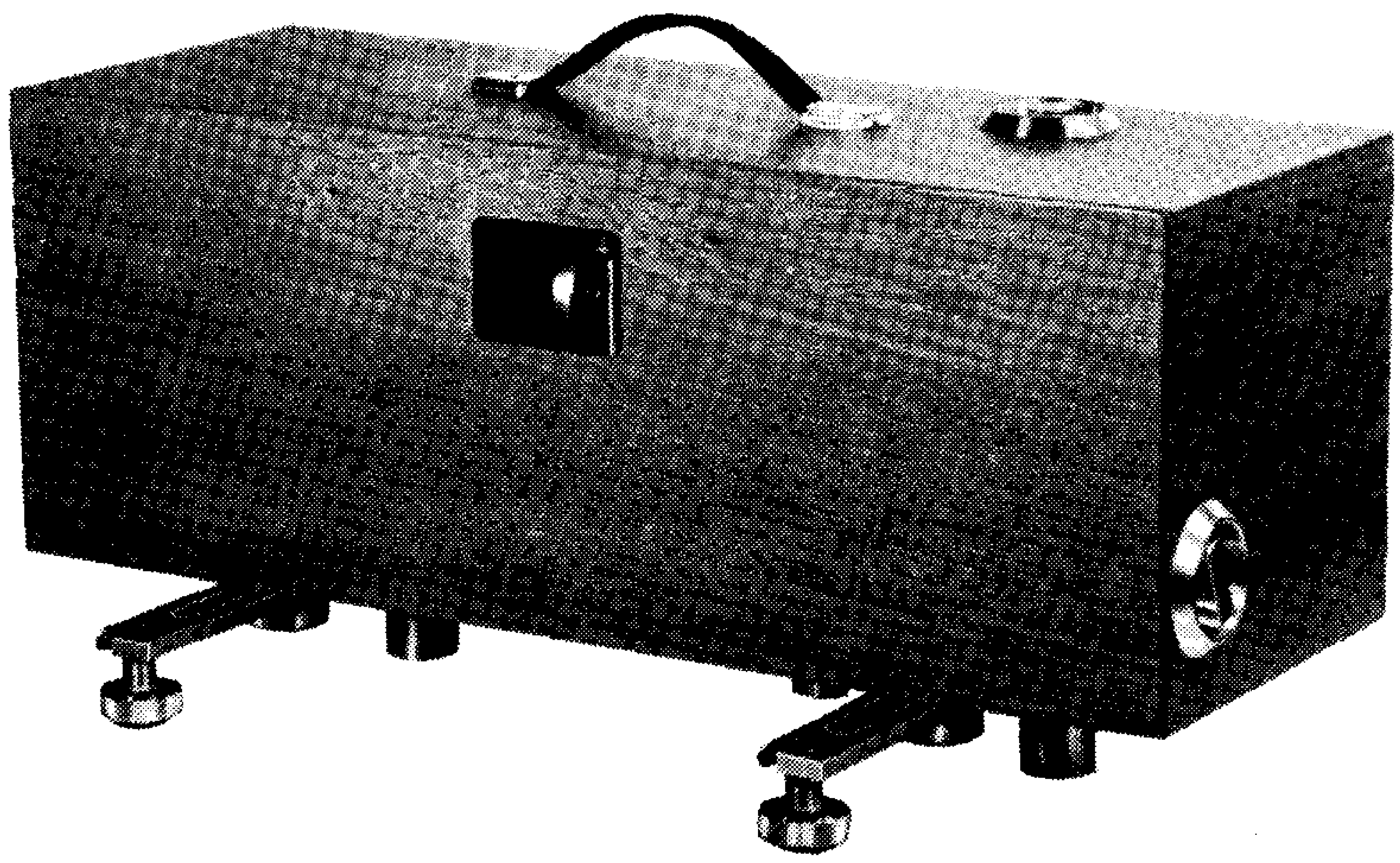


*Fig. 5. Brüel & Kjær experimental model of Tapping Machine where the feet can be located at different distances from the hammers.*

A series of measurements were made with the machine supported as follows:

1. with standard metal supports.
2. with metal feet capped with 3 mm thick plastic.
3. with the feet capped with 5 mm thick rubber.
4. with the same rubber feet but placed 6 cm from the hammers, and
5. with the rubber feet placed 10 cm from the hammers.

In order to obtain the greatest differences in measuring results, by making the coupling between the vibrating floor and the machine as pronounced as possible, the machine was placed as shown in Fig. 6, i.e. very thin light floor resting on wooden slats again placed on 10 cm thick reinforced concrete. To ensure that the wooden part of the floor would vibrate as much as possible, no glass wool was used between the floor and the concrete. The sound pressure in each third octave was very carefully measured in the room below with a Condenser Microphone and Selective Amplifier and then recorded on a Level Recorder.

Typical results are shown in Fig. 7 where some fluctuation in sound level can be observed with the lower frequencies. This is to be expected as a very limited number of natural modes are excited in the receiving room. By having fixed positions for both the Tapping Machine on the floor above and the

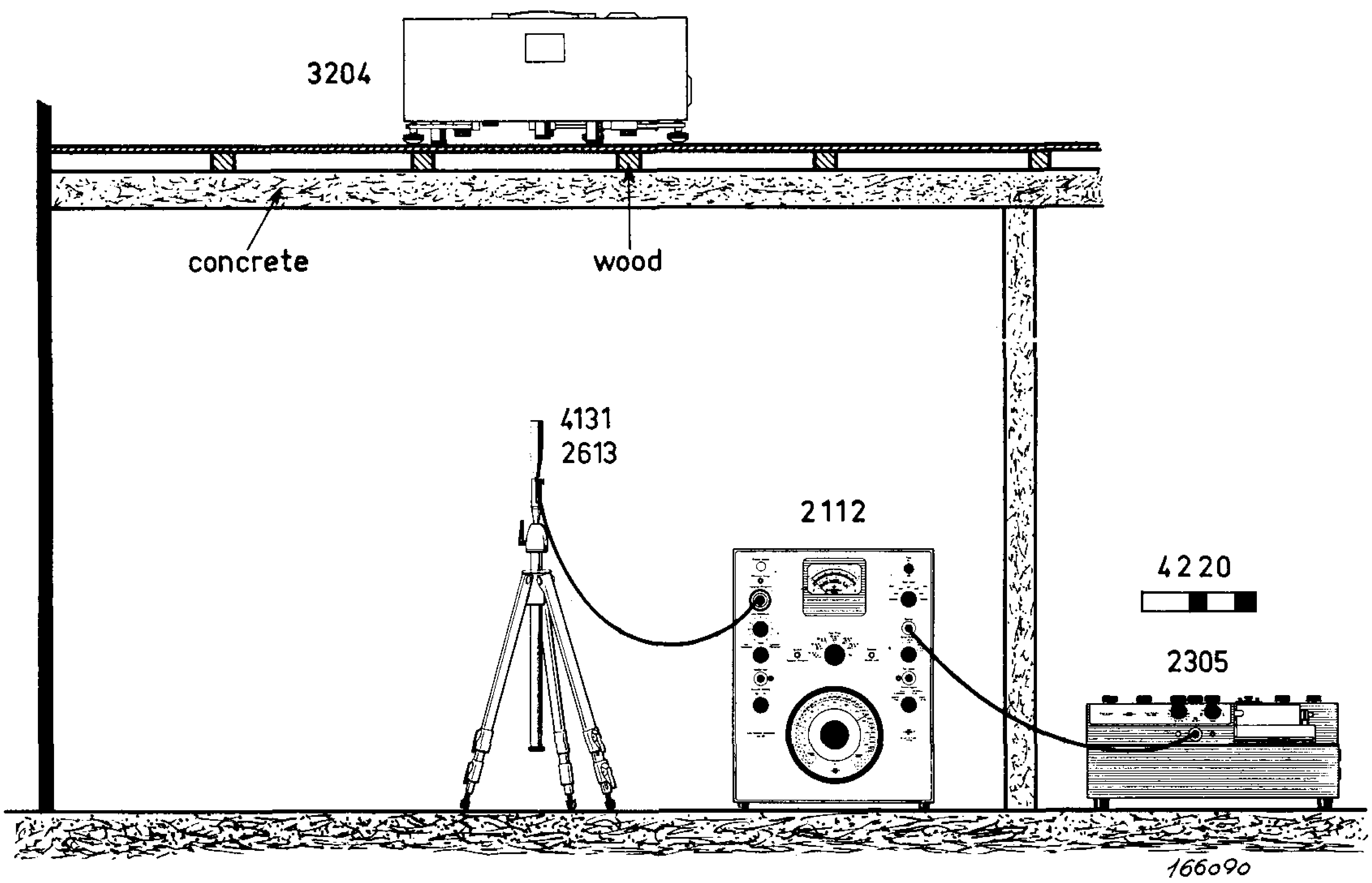



*Fig. 6. Principle of the measuring arrangement for testing the coupling between the vibrating floor and supporting legs of the Tapping Machine. The construction of the floor used is also indicated.*

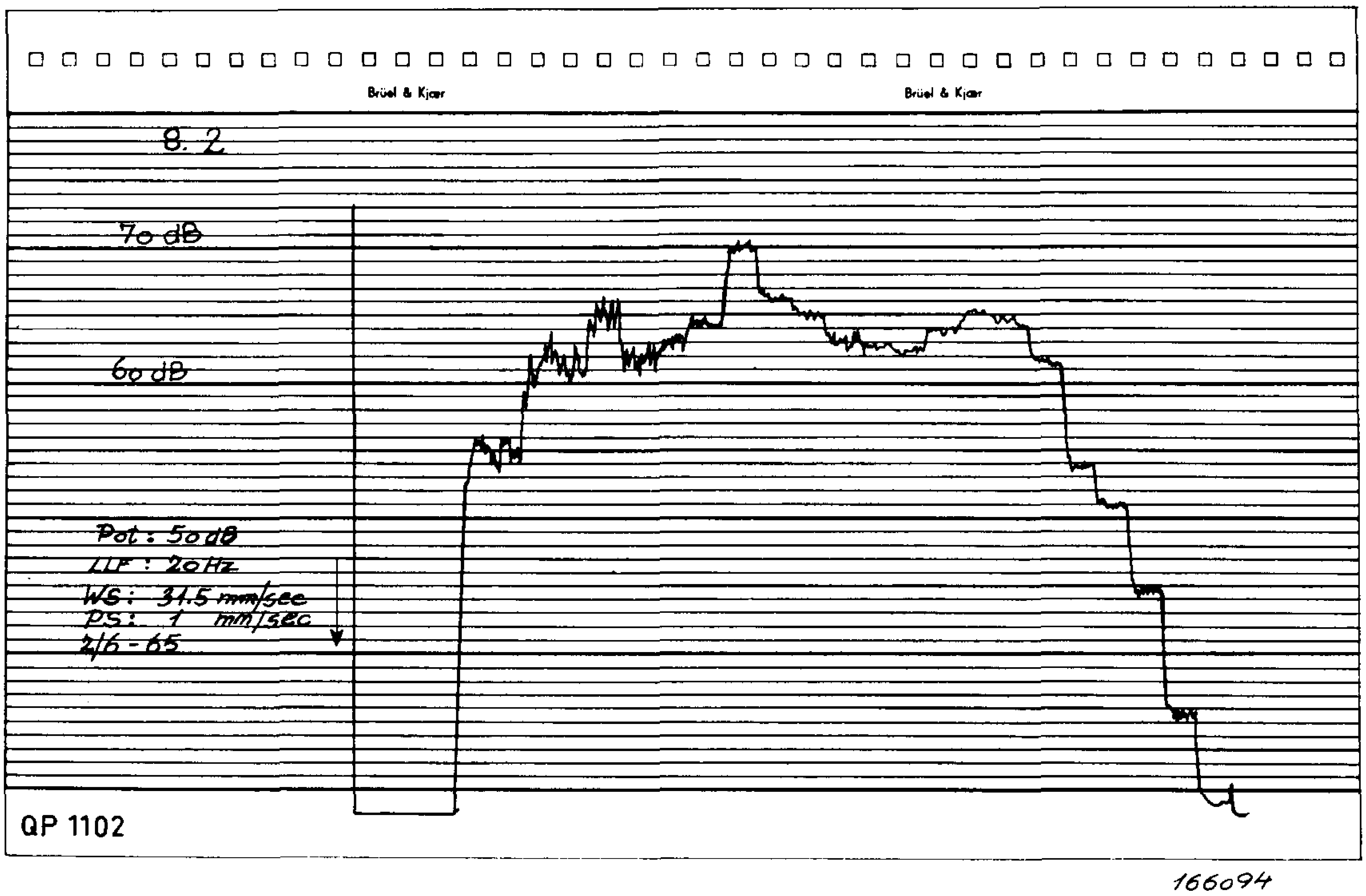



*Fig. 7. A typical example for recording SPL in the receiving room in third octaves.*

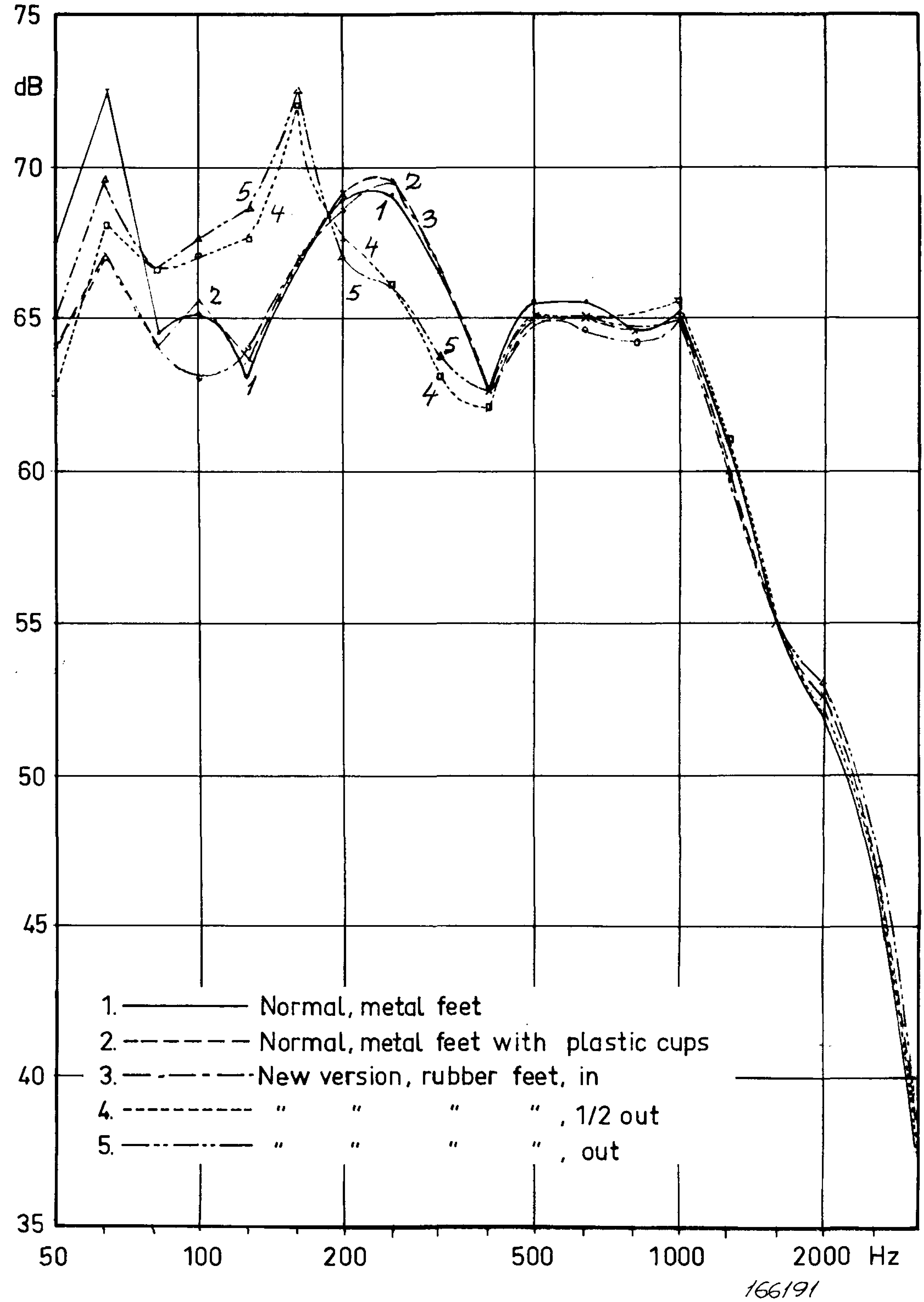



*Fig. 8. SPL's with the experimental Tapping Machine when the different supporting feet were placed on the wooden floor covering a 10 cm concrete slab.*

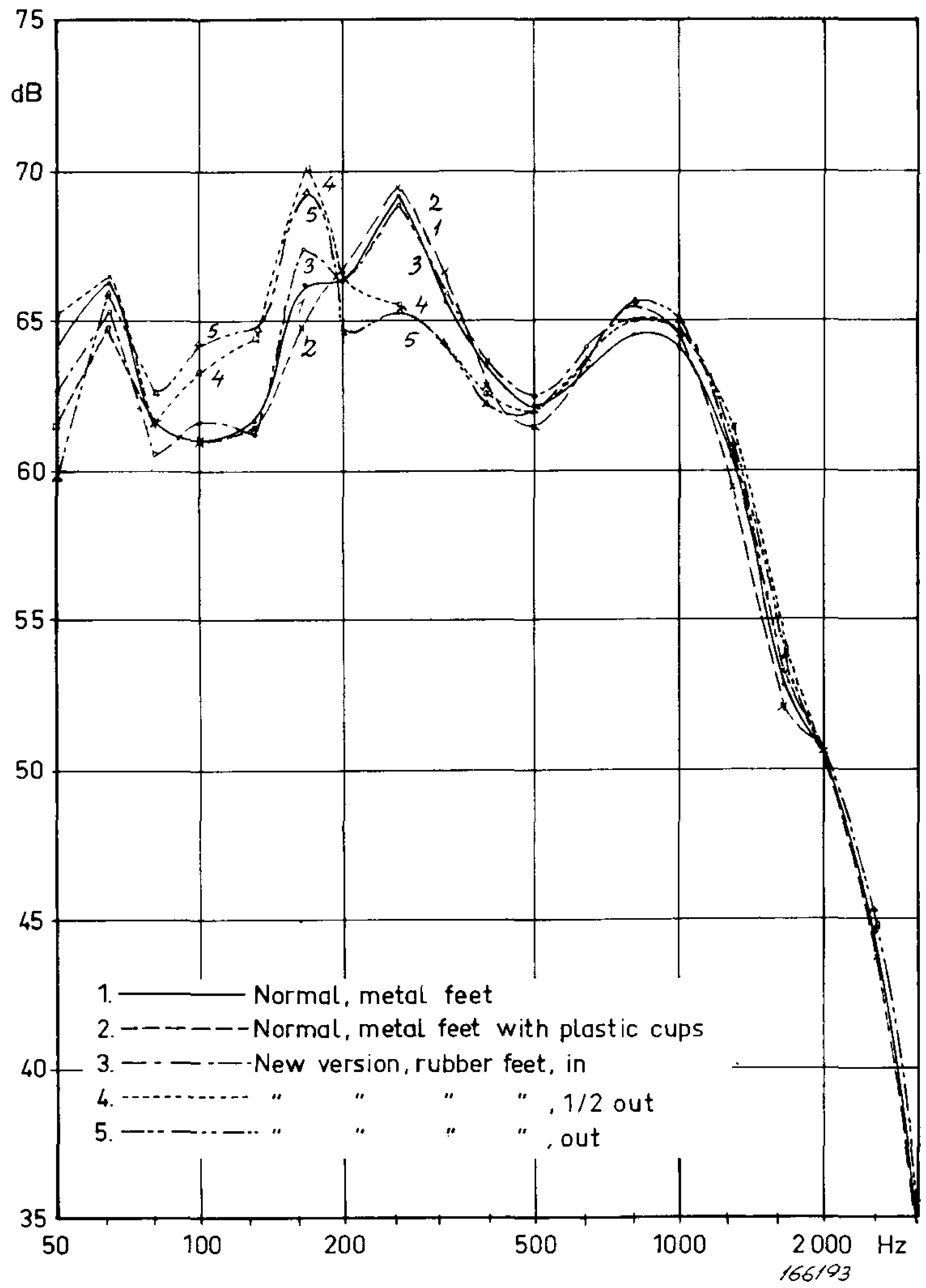



*Fig. 10. Same as Fig. 8 but where a piece of linoleum is placed under the Tapping Machine.*

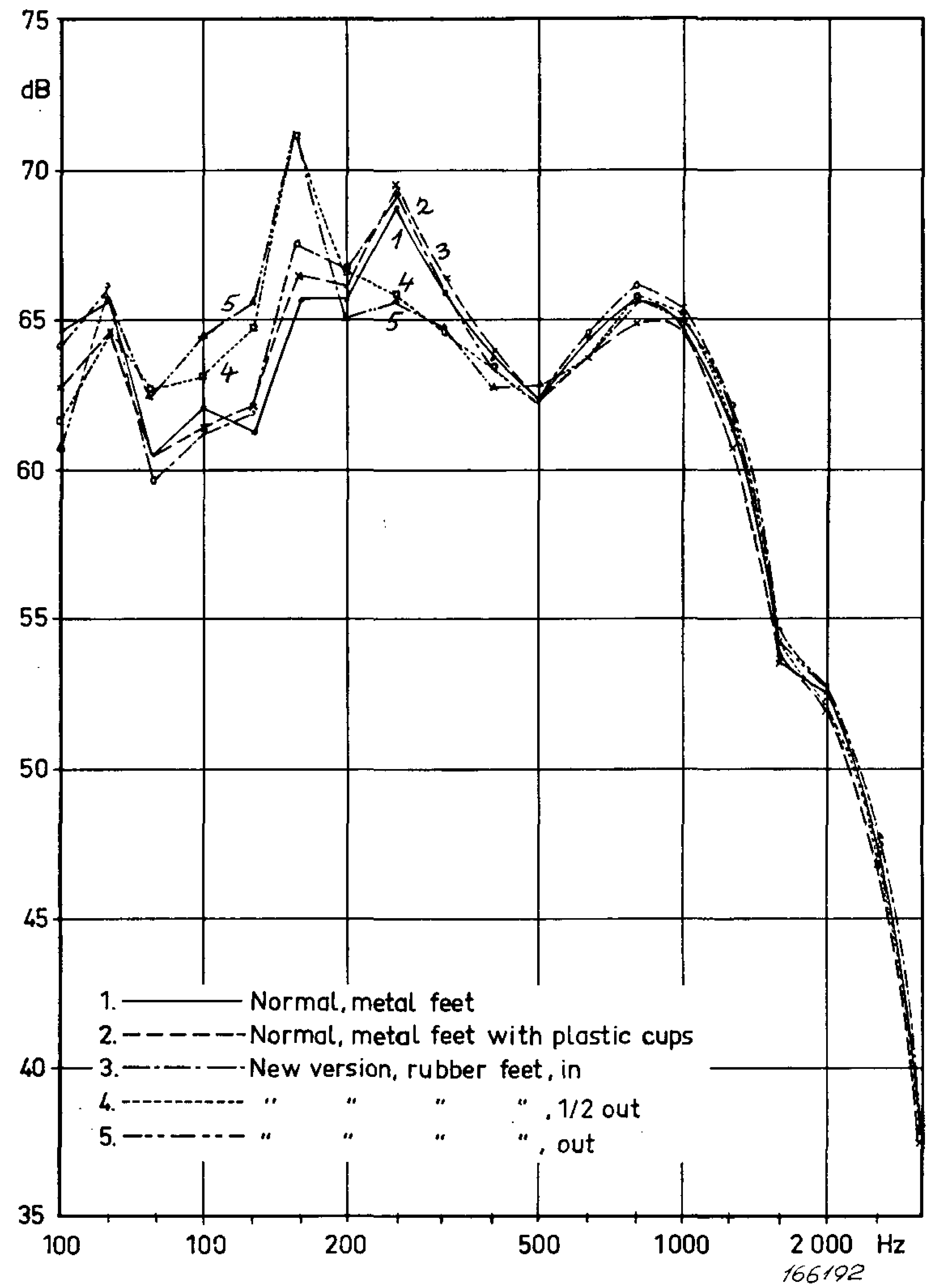



*Fig. 9. Same as Fig. 8 but where the Tapping Machine is located in a different position.*

microphone in the receiving room, differences can very easily be recorded and, in general, a high degree of accuracy can be obtained. The overall accuracy in the measurements is ± o.8 dB. By calibrating the microphone amplifier and Level Recorder with a Pistonphone, the uncertainty of the sound pressure level can be minimized to o.3 dB. The actual measuring results are set out in the curves shown in Figs. 8, 9 and 10, where five curves, representing the different leg and feet combinations are shown on each figure. Figs. 8 and 9 show measurements from the wooden covered concrete floor, but at two different positions of the Tapping Machine. Fig. 10 shows results where the Tapping Machine is in the same position as in Fig. 8 but the floor is covered with 2.5 mm thick linoleum. From all these measurements it is seen that the normal metal feet, the feet capped with plastic and even the feet capped with rubber, give some coupling to the floor construction: but by moving the feet away from the hammers, this coupling was made sufficiently small. On the other hand, there is no difference if the distance from the hammer is either 6 or 10 cm, indicating that 6 cm is sufficient. It will be observed that the German investigations show that covering the feet with

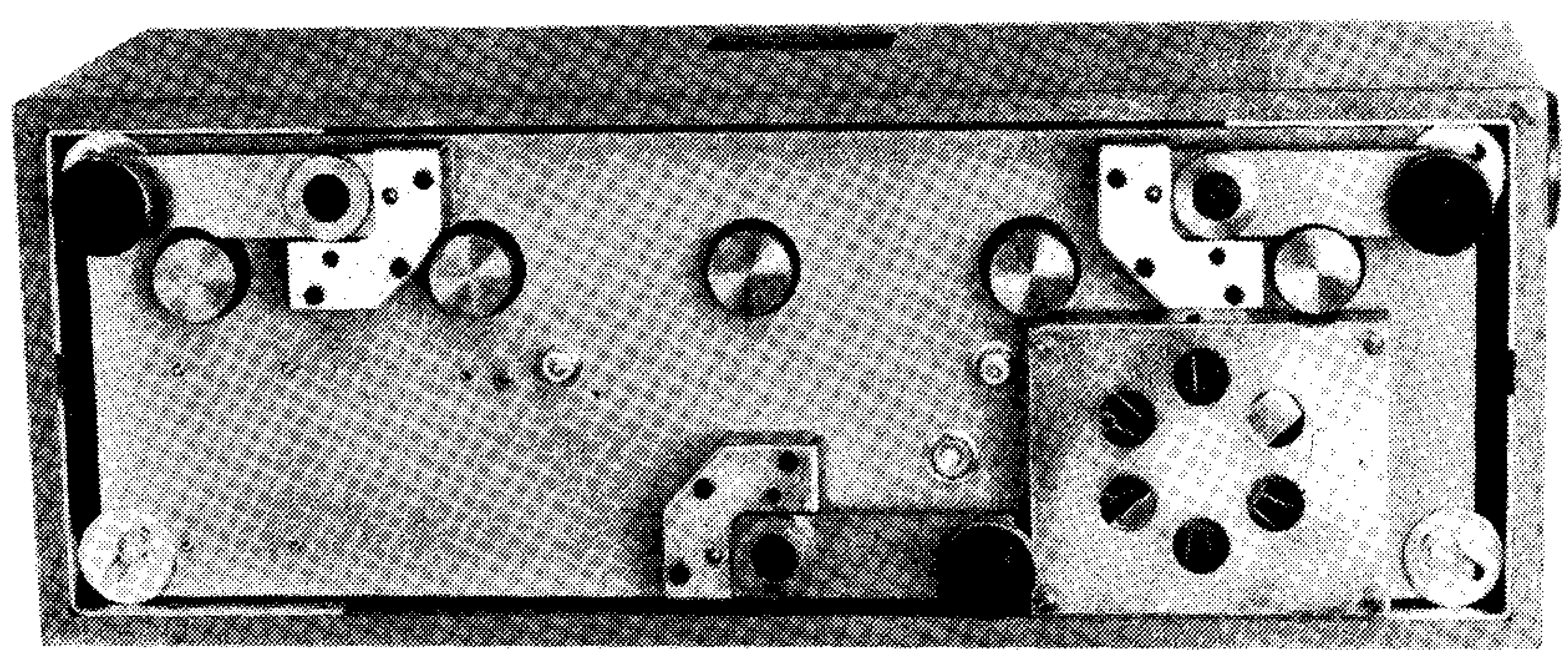


*Fig. 11. View of the underside of the new version of the Tapping Machine where the feet are shown in the "in" position.*

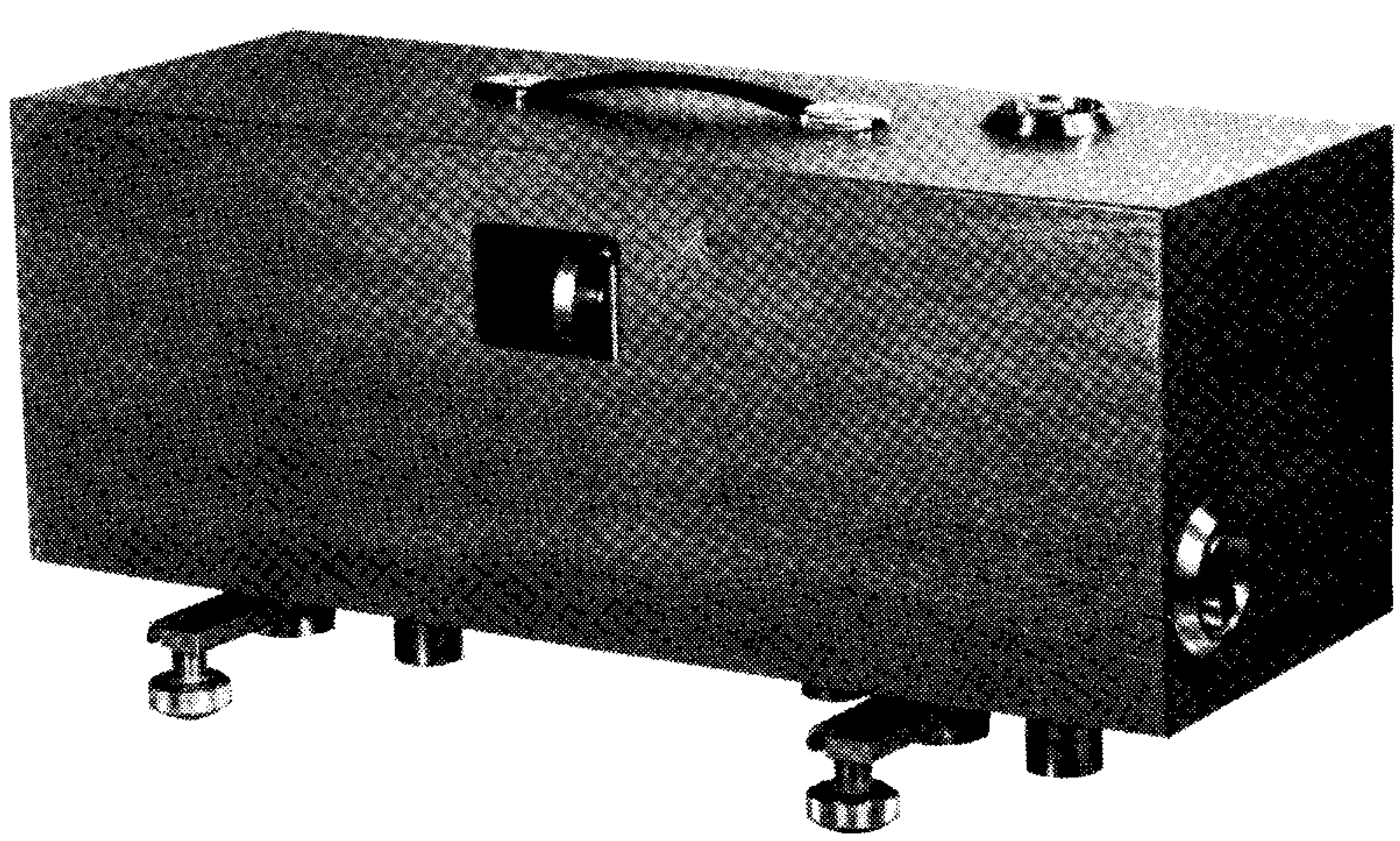


*Fig. 12. New version of the Tapping Machine with the feet in the "out" position.*

rubber, even if the feet were placed close to the hammers, was enough to make the coupling effect negligible, but our experiment shows that a displacement of the feet is also necessary.
We have taken the consequence of these measurements and have changed the feet arrangement on the Tapping Machine 3204 by mounting them on a swinging arm as shown in Fig. 11 so that when the feet are in the inner position the dimensions of the machine, and therefore the ease of portability, are not effected. When the Tapping Machine is in use the arms are turned so that the feet will be in the outer position and located more than 10 cm from the hammers as shown in Fig. 12.
This modification with the feet on swinging arms can also be fitted to older Tapping Machines.

**References.**

1. ISO (International Organization for Standardization) Recommendation R140 "Field and Laboratory Measurements of Airborne and Impact Sound Transmission" January 1960.

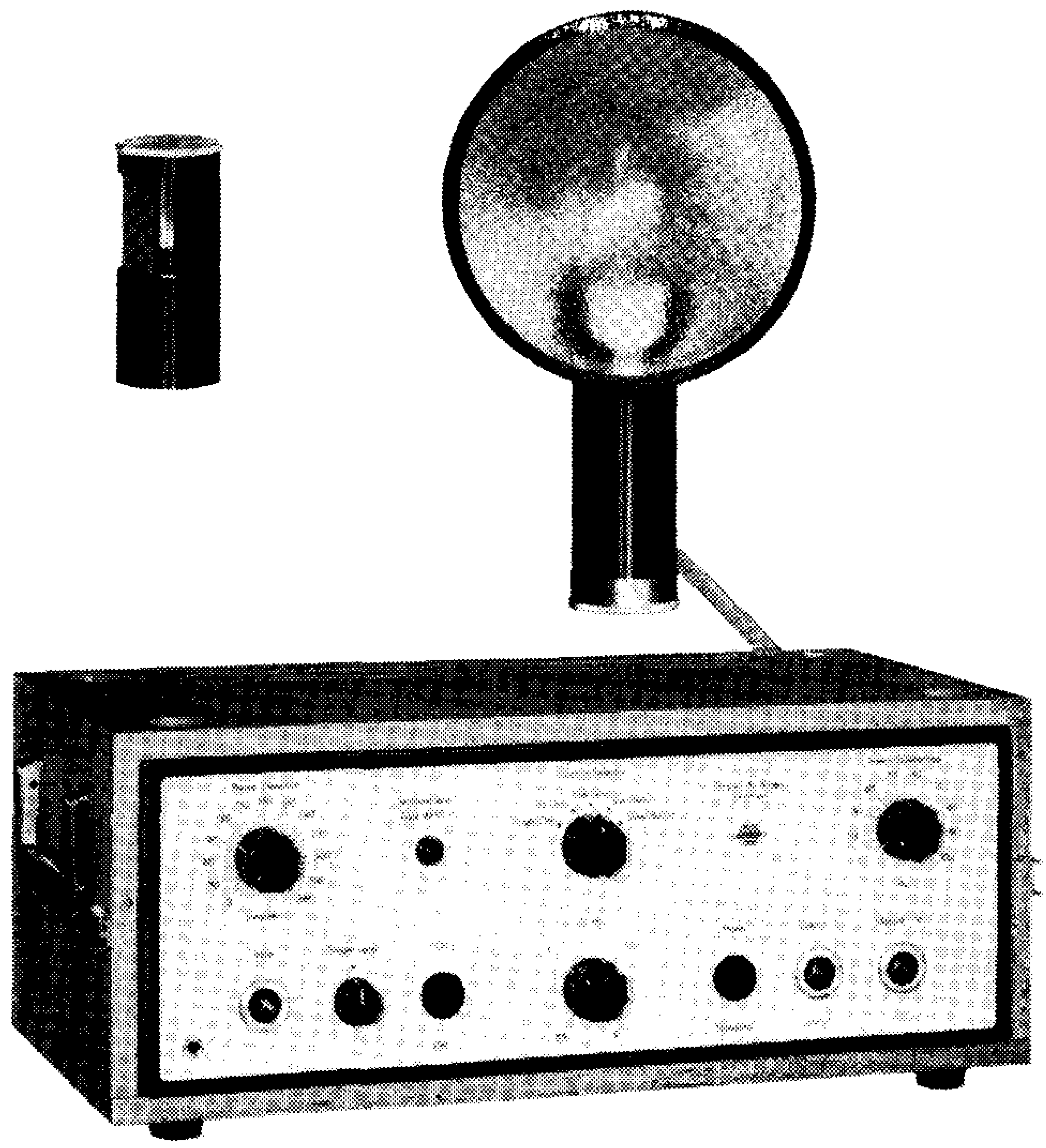
2. Instructions for use of Brüel & Kjær Tapping Machine Type 3204, Copenhagen, August 1962, see also Main Catalogue 1965, page 193.

3. G. Venzke, P. Dämmig and J. Bärner: Untersuchungen an Trittschall-Hammerwerken verschiedener Bauart, PTB-Mitteilungen, Amts- und Mitteilungsblatt der Physikalisch-Technischen Bundesanstalt, Braunschweig, Heft 2/65, Seiten 120 bis 123, Deutscher Eichverlag GmbH., 1 Berlin 30.

# News from the Factory

**Stroboscope Type 4910.**

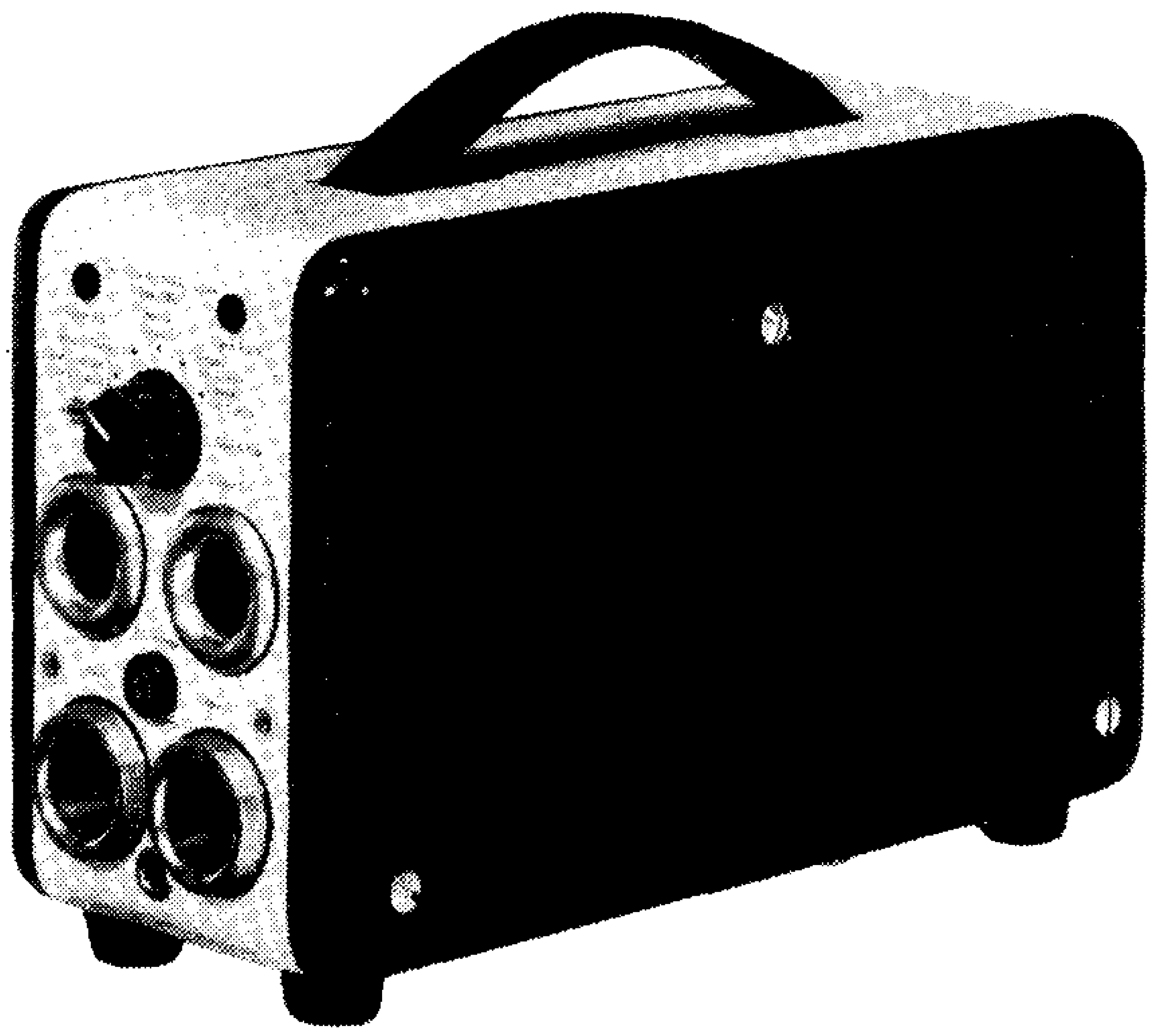
The Stroboscope Type 4910 is designed for the purpose of visually stopping or slowing down all kinds of vibrating rotating and reciprocating periodic movements within the frequency range 5 Hz (300 RPM) to 10 kHz (600ooo RPM). *It is intended for use in education, laboratories and industry* as a reliable means for the study of vibrational phenomena such as mechanical resonances, unbalance in rotating objects, plate and membrane vibration as well as for the inspection of running mechanical gears, cog-wheels etc.
The instrument contains two separate sawtooth generators, one of which is controlled by a square wave pulse from the input circuit and thus of the same frequency f as the input signal. The other sawtooth generator generates a signal of the frequency $\Delta$ f, which is variable from o.5 to 2 Hz. The two signals are compared, and by means of a count down circuit the resulting signal f + $\Delta$ f is divided by a factor n, which increases proportionally with the frequency f. This means that although the upper limiting frequency of the input is 10ooo Hz, the flash rate does not exceed 110 flashes per sec.
Above 50 FPS the flashes begin to appear as steady light, and to obtain a light intensity as homogeneous as possible the maximum flash rate of 110 FPS



has been found suitable. When the flash is synchronized with a periodically vibrating test object, this is visually stopped and by means of a phase deviation knob the object can be viewed in any position of its cycle which is an advantage when maximum displacement at resonance has to be measured.
Also rotating and reciprocating objects can be phase positioned and irregularities, which are normally difficult to investigate, may be observed.
In cases where an external synchronization signal is not available, an Internal Generator can supply the pulses for the Flash Unit. All vital parts in the Stroboscope are of the plug-in type and solid state electronics are incorporated throughout, including monolithic integrated circuitry.

**Two-Channel Power Supply Type 2803.**

The Two-Channel Power Supply Type 2803 is intended for use in connection with two of the B & K Cathode Followers Type 2612-13-14-15. It delivers anode, filament and polarization voltages, and converts the output impedance of the cathode followers into a much lower impedance, this being necessary when very long cables have to be used between the microphones and the succeeding amplifier.
It will allow the use of two channels simultaneously, or enable switching either manually or automatically between the two channels to one set of recording instrumentation connected to the output. Both channels may be conditioned to any desired level between 0 and −40 dB rel. to the nominal sensitivity of the input transducer. The resolution is very high close to 0 dB but decreases considerably however at −40 dB.



The Two-Channel Power Supply can also be used as an impedance converter for the B & K vibration pick-ups when used in conjunction with one of the Cathode Followers 2612-13-14-15-17. This gives a conversion of impedance from 300–1200 MΩ (depending on the type of cathode follower) to 15 Ω in series with 5 μF, which is the output impedance of the Two-Channel Power Supply, thereby allowing remote monitoring of the pick-up output.

The Two-Channel Power Supply Type 2803 contains a built-in automatic channel selector which is able to connect the two input signals alternately to the output at a recurrent frequency of approximately 0.5 Hz. The switching can also be controlled externally for instance by means of the Level Recorder Type 2305 or simply by grounding an external control lead.

We wish to take this opportunity to inform the readers of Technical Review that as from No. 1 1967 the Review will also be available in German and French. When requesting either of these two new editions please quote your mailing list number.

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