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THE MAGNETOPHON SOUND RECORDING AND REPRODUCING SYSTEM

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

RESEARCH DEPARTMENT

GERMAN MAGNETIC RECORDERS
THIRD REPORT: THE MAGNETOPHON K. 7.

Report No. C.053/3.
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and doubt was expressed as to whether the latest type of tape (LG) is, in fact, superior to the earlier types. It has since been learned that the LG tape has proved unsatisfactory in service and that the earliest kind of tape (type C) is now generally used in Germany. No further information is available concerning the uniformity of this tape from spool to spool.

THE RECORDING MACHINE

This is very similar in layout and construction to the H.T.S. recorder, but the main motor is synchronous and the take-up and rewind spools are driven by induction motors. The latter are very satisfactory in operation, and the addition of a switch giving two forward and two reverse speeds facilitates editing. The main motor, however, is rather deficient in torque and it will not synchronise if the pressure on the rubber idler wheel is too great or if the temperature or the line voltage is low. When the machine is first started from cold it usually fails to synchronise until after several minutes running and during this time the tape speed fluctuates widely.

A rough timing indicator is gear driven from an idler wheel which guides the tape on to the take-up spool. The edge of this idler is illuminated by a neon lamp connected across the mains input, and is painted to form a stroboscope giving a stationary pattern at 300 r.p.m., corresponding to a tape speed of 77 cms/sec. The purpose of the stroboscope is not clear, for the tape speed cannot be adjusted, except by changing the driving sleeve on the main motor, and failure of the motor to synchronise is indicated clearly enough by a characteristic noise from the motor.

As on the H.T.S. machine there is a safety catch in the form of a horizontal plunger which must be moved before the "Record" push button can be depressed. This is to prevent the "Record" button being moved inadvertently, for this would energise the wiping head and so destroy any recording that might be on the tape. On the K.7 the safety catch is placed in a recess in the top plate so that the operator's action in releasing it must be very deliberate. The brakes fitted to the motors are similar to those on the H.T.S. machine but the operating solenoids are mounted vertically so as to facilitate brake adjustment.

Means are provided for placing a cue mark on a tape and

for using this mark to control the starting of another machine so that reproduction from two or more consecutive tapes may be linked together without the change from the end of one to the beginning of the other being noticeable. As the recording on one spool nears completion a knurled knob is rotated and this places a piece of sticky metal foil on the active surface of the tape. At the same time it operates a switch which, by means of a relay unit, starts recording on a second machine. When reproduction of the first spool nears completion the metal foil passes the reproducing head and then short circuits a pair of contacts, so operating the relay unit and starting the second machine. If this machine has been set up, stationary, but with the beginning of the recording on the second spool close to the reproducing head, then provided that the tape reaches full speed quickly after switching on, reproduction from the two machines will be synchronised and one may be switched into circuit and the other out at any convenient time until the spool on the first machine is finished. As only one machine was available it was not possible to test the effectiveness of the arrangement in operation.

The power consumption of the recording machine when running is 220 volt-amps. The wiring diagram is shown in Fig.1.

HEAD ASSEMBLY

The recording, reproducing and wiping heads and the casing in which they are assembled are all similar to those used on the Magnetophon H.T.S. but in the K.7 only the reproducing head is magnetically screened. Also the alignment of the recording and reproducing heads can be adjusted while the machine is running by means of screws which project through the top of the casing and rotate the tapered washers on which the heads are clamped. This is an important improvement, for on the H.T.S. equipment, adjustment of the head alignment was both tedious and uncertain, unless a travelling microscope was available. For satisfactory operation of a single machine it is sufficient if the alignment of the reproducing and recording heads correspond, but if it is required that the recordings from several machines shall be interchangeable it is, of course, necessary to ensure that the alignment of all the recording heads is identical.

The K.7 recorder is also provided with a retractable guide which may be used to lift the tape out of contact with the heads when rewinding, and by this means wear on the heads can be reduced.

THE AMPLIFIER UNIT

The amplifier unit is divided into two parts. Below is the monitor or microphone amplifier with its self-contained mains unit, and

above it is an assembly containing (1) the recording amplifier, together with the bias and wiping oscillators (168 kc/s and 42 kc/s respectively), (2) the reproducing amplifier and (3) a mains unit. Each of these three units has a plug connector and the three are mounted together in a steel chassis which, like the monitor amplifier, slides into a steel framework carrying the sockets and inter-connecting wiring.

THE RECORDING AMPLIFIER

As shown in Fig.2 the recording amplifier has three stages with a "top-tip" circuit (resonant at approximately 10 kc/s) connected between the first two. The frequency characteristics obtained with three settings of the "top-tip" control are shown in Fig.3 and the harmonic content of the current through the recording head at various levels is shown in Fig. 4. The input impedance is sensibly constant at 200 ohms. and at full gain an input of 6 db. above 0.775 volts is required to give the maximum recording current of 5 mA.

The two oscillators that supply the bias and the wiping currents have tuned anode circuits with screened coils and their frequencies are locked in the ratio of 4: 1 (168 kc/s and 42/s). By this means the production of audible heterodyne notes, which were troublesome on the H.T.S. equipment, has been avoided. No means are provided for adjusting the wiping current and the 110 mA obtained on this equipment appeared to be rather inadequate since, after wiping, traces of a previous recording could still be heard amongst the background noise. The bias current was also not adjustable but the value of 10 mA that was obtained appeared to be satisfactory. The audio current was set to the value indicated by the marking on the meter, i.e. to a maximum current of 5 mA.

An unusual arrangement of the grid-cathode circuit of the output valve of the recording amplifier should be noted. When the machine is not recording the H.T. supply is switched from the anode to the cathode circuit where it produces a bias of about 20 volts. This arrangement is apparently adopted so that, on switching to the "Record" condition, the comparatively slow discharge of the 1.0μF condensers C.56 and C.57 (Fig.2) will ensure a gradual rise of anode current and prevent surges which might magnetise the recording head. No switching is provided between the amplifier and the recording head, whereas on the H.T.S. equipment a switch in this position was arranged to close after the H.T. supply had been connected to the recording amplifier.

THE REPRODUCING AMPLIFIER

This amplifier, the circuit diagram of which is shown in Fig.5, has two stages, followed by a low pass filter for removing supersonic frequencies. The amplifier includes a frequency weighting network, but the 6 db. per octave slope of the frequency characteristic that is required to compensate for constant current recording is obtained by making the input impedance low compared with that of the reproducing head. As the response depends greatly on the impedance of the reproducing head the frequency characteristics shown in Fig.6 were taken using the German test procedure, that is to say by injecting in series with the reproducing head a voltage proportional to frequency. The variable "top-tip" control, which consists of a series tuned circuit connected between anode and ground, operates by varying the feedback on the first stage and its effect is shown in Fig.6. It was found that, owing to Miller effect, the gain control also varies the frequency characteristics to some extent, and this also is shown in Fig. 6.

Before the equipment arrived here the input transformer, which was inadequately screened, had been replaced by an equivalent BBC type in a mumetal box, and it was found that this had reduced hum by 14 db. It was observed also that although the valves are elastically mounted microphony was troublesome unless some vibration isolation was interposed between the amplifier and the recording machine.

The output impedance of the amplifier is approximately 200 ohms. and the output level at 1 kc. for line-up is 10 db. below 0.775 volts.

THE MAINS UNIT

This unit delivers a smoothed H.T. supply of 240 V. 66 mA for the recording and reproducing amplifiers and an A.C. supply of 6.3 V. 2 A. for the valve heaters. As shown in Fig. 5 it is of fairly conventional design but the use of a 25 μF reservoir condenser with a valve rectifier is unusual. The smoothing, however, is rather inadequate for the hum level at the output of the recording amplifier was reduced more than 10 db. when the recording and reproducing amplifiers were fed from a BBC mains unit.

THE MICROPHONE OR MONITOR AMPLIFIER

This is a two stage amplifier with a self-contained mains unit and it can be used either to feed the recording amplifier from a microphone or to feed a loudspeaker for comprehensive checking. The output impedance is 15 ohms. and the maximum gain 80 db. As shown on the circuit diagram of Fig. 7 a peak programme meter is included but its

time constants are somewhat different from those of the BBC peak programme meter. Separate two position switches are provided for inserting a bass tip when the amplifier is used for monitoring and for inserting a bass cut when it is used as a microphone amplifier. The effect of these controls on the frequency characteristic is shown in Figs. 8 and 9 which also indicates how the frequency responses vary with the position of the gain control.

OVERALL PERFORMANCE

Measurement of the signal to noise ratio showed that the noise voltage in the output was approximately 43 db. below maximum signal level (35 db. below line-up). This relatively high level of noise voltage is not primarily due to the tape itself, but to hum produced in various parts of the equipment. It was found that inserting a 100 c/s high pass filter reduced the background noise by 10 db. and it was only when the cut-off frequency was raised to above 800 c/s that the background noise was greatly reduced. This is perhaps not surprising when it is remembered that the noise level is brought to its present value only by adjustment of a hum bucking coil which reduces the noise voltage by 15 db. This coil is connected in series with the reproducing head but is mounted remotely from it and close to the main motor. When listening to the reproduction of music, the background noise is generally less disturbing than the high value of the noise voltage would suggest, for the background is low pitched and fairly steady so that while it is obvious enough when comparing a recording with the incoming programme, it is easily forgotten or accepted as part of the original signal. It is usually more noticeable when reproducing speech. In all cases the annoyance value of the background noise is very dependent on the listening level for there are low frequency rumbles, the loudness of which increases rapidly as the listening level is raised.

Fig. 10 shows the total harmonic distortion when tones of 200 c/s and 2500 c/s tone were recorded at various levels and as a more comprehensive check on quality listening tests were carried out on a variety of types of programme material. As the frequency characteristics of both the recording and reproducing amplifiers are variable at the higher frequencies, (Figs. 2 and 6) tests were made at approximately the extremes at which a sensibly flat overall response could be obtained. The resulting recording characteristics (variation of recording head current with frequency) are shown in Fig. 11a and the corresponding overall responses in Fig.11b. It was not possible to obtain a completely flat response at the higher frequencies with the existing controls though this would clearly be possible with more suitable weighting networks.

Listening tests carried out with both recording characteristics shown in Fig. 10a showed no striking difference in the results obtained, though on the whole the characteristic shown in curve 1 (maximum "top-tip") was preferred. This might be merely because the overall response was a little better. It is noteworthy that no significant difference in background noise was observed between one recording characteristic and the other, and this confirms that high frequency noise from the tape is a negligible part of the total background noise. The recording level was not critical since the increase of distortion with level was very gradual.

Generally speaking the quality of reproduction was found to be very good though it was observed, when recording high quality programme, that there was a general and characteristic kind of distortion, which did not vary very much with the signal level. No obvious "wow" was present but it was evident on comparison with a simultaneous reproduction of a 78 r.p.m. disc being cut on the Type D recorder, that the Magnetophon speed constancy was inferior and its reproduction was less clean. Nevertheless, the quality obtained from the Magnetophon was high enough for these deficiencies to be noticeable only when recording a very high quality programme. Listening to music at moderate levels the background noise was satisfactory but at higher listening levels, or when reproducing speech, the background noise was noticeable.

CONCLUSIONS

The performance of the K.7 equipment is slightly better than that of the H.T.S. and while the quality is inferior to the best that can be obtained from discs it is good enough for all purposes except for fairly critical listening to recordings of high quality programmes. The reasons for the superiority of the performance of the K.7 over the H.T.S. Magnetophon are not at present known, for measurements of the amplifier distortions do not indicate any significant improvement in this respect.

It might be possible with some modification to reduce the slight distortion of the equipment, but the extent to which this might be practicable could be determined only by an investigation of the magnetic recording process. It would appear to be comparatively easy, however, to eliminate the more important defects of a relatively high hum level and barely adequate speed constancy by suitable redesign. The equipment is by no means up to BBC standards as regards hum level and microphony, and, of course, the variation of amplifier frequency characteristic with the setting of the gain control is a feature which would not normally be tolerated in a BBC design.

While the performance is satisfactory for nearly all purposes the equipment is hardly suitable for operational use without some modification. For example, the recording and reproducing characteristics and the alignment of the recording and reproducing heads are all adjustable, and, as it would be essential for recordings made on different machines to be interchangeable, it would at the least be necessary to provide means for standardising the adjustments and for locking the controls in the appropriate positions. In addition to replacing or improving the screening of the reproducing amplifier input transformer, which has already been mentioned, it would also be necessary to change the input transformer of the recording amplifier and the output transformer of the reproducing amplifier to suit the BBC line impedance of 600 ohms. The recording amplifier would then require a line-up level input of approximately + 3 db. and the reproducing amplifier would deliver a line-up level of approximately - 5 db. to line.

H L Kirke

(H. L. Kirke)

MES

H. M. STATIONERY OFFICE
PHOTOGRAPHIC SECTION

MICROFILM REPRODUCTION OF B.I.O.S. F.R. 751.

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FILM ROLL NO. ONE (COMPLETION)

FRAME NOS. 1 TO 120.

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WORK DOCKET NO. 16036.

CAMERA NO 945

THE MAGNETOPHON SOUND RECORDING AND REPRODUCING SYSTEM

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BIOS Trip No: RAT 43.

BIOS Target Numbers:
See page No.1.

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE
32 Bryanston Square,W.1.

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Personnel of Team

M.J.L.Pulling (British Broadcasting Corporation)
E.M.Payne (Electric & Musical Industries Ltd.)
H.E.Parker (Ministry of Supply)

See FD 1186/47

1 SUMMARY

This report describes a system for the recording and reproduction of sound, making use of the well-known magnetic principle, which has been developed in Germany both before and during the war.

During the war an improvement in performance has been achieved and the quality of reproduction of speech and music now obtainable by means of this system is of a high order and, it is claimed, consistently better than that achieved with other systems.

There are two principal novelties, firstly the use of supersonic frequency A.C. for biassing (premagnetising) as well as for wiping (erasing) and secondly the use as recording medium of a tape whose magnetisable layer consists of a dispersion of iron-oxide particles in a plastic material. It should be noted that the use of A.C. for biassing was being developed at about the same time in the U.S.A., notably by the Armour Research Foundation of the Illinois Institute of Technology, Chicago, though the recording medium in this case was a thin steel wire.

These two new features in combination have resulted in improvements in frequency response, harmonic distortion and in the relative strengths of programme and background-noise (signal/noise ratio).

The firms principally concerned in the development were:-

Allgemeine Elektricitäts Gesellschaft (AEG)
for the machine C7/214, C9/714.

I.G.Farbenindustrie (I.G.Farben)
for the tape C7/511, C9/1121.

Magnetophon G.m.b.H, 39 Karl strasse, Berlin, which was formed as a subsidiary by AEG and I.G.Farben, and in which each had a 50% interest, for the exploitation of the system. C7/512, C9/475.

Important contributions to the development were made also by the Reichs Rundfunk Gesellschaft (RRG) - the German Broadcasting organisation - and in particular by its chief engineer, Dr.H.J.von Braunmühl and by Dr. Walther Weber (deceased).

A considerable number of different types of Magnetophon equipment has been manufactured for various more or less specialised purposes and others are either just coming to fruition or in contemplation. Some use A.C. for wiping and biassing, whilst others use the older method employing D.C. These different types are described in Section 5.

In December 1945 the position regarding manufacture in Germany (excluding the Russian zone which, of course, was not investigated) was that no manufacture of any model was in progress. In the factory of AEG, 35 Drontheimer strasse, Berlin (French Sector) assembly of about 30 machines type K7 was in progress. Most of the parts for these were available but it was stated that further production would be impossible until fresh tools, etc. had been made. Steps have been taken by the Ministry of Supply towards obtaining a number of these, to be made available to interested parties when received in U.K.

No attempt has been made to assess what stocks there may be of any types of Magnetophon recorders amongst captured enemy equipment. It is known that a number of the high quality machines (mostly type HTS) are in use by Nordwestdeutscher Rundfunk (North West German Radio) and by Radio Frankfurt and it is almost certain that some of these are in the hands of the broadcasting authorities of ex-enemy-occupied and neutral countries. It is also known that a number of the lower quality machines (A 1000 L 40 and probably Tonschreiber b) are in use by British Army Signals for monitoring purposes. The Royal Navy have also taken considerable interest in the Magnetophon and it is probable that they have a number in use. Small quantities of various types have reached U.K. and are mostly in the hands of the Services and other Governmental organisations.

The development of the tape has passed through three clearly defined stages: the earliest type produced, type C, used black magnetite (Fe_3O_4) whilst the later type L used red magnetite (Fe_2O_3). Both these types were homogeneous. Type LG, the most recent, consists of a "carrier" layer of non-magnetic material, basically polyvinylchloride, which is coated with a thin layer of red magnetite dispersion similar to that used in the type L.

In December 1945 tape was being manufactured only at Wald Michelbach in the U.S. Zone, where the output was of the order of 3,000 reels per month, type LG. There has been talk, however, of setting up a plant for producing this tape at the I.G.Farben factory at Troisdorf in the British Zone.

Enquiries were made about patents, from which it appears that a considerable number have been granted, from 1930 onwards, and a number of applications are still outstanding. Section 7 contains information on the numbers of the patents and applications and other details. Quite apart from any question of rights in these patents, some are of interest in themselves for the technical information which they reveal.

Consideration was given to the desirability of recommending the evacuation of plant in connection with these instruments. It was concluded that there was little point in this as the machines appear to be of straightforward design and the manufacture of similar machines should be within the capabilities of an organisation accustomed to high-precision mechanical construction. The amplifiers and equalisers employ normal known technique and are in no way specialised. Mechanical drawings of the Magnetophon type K7 may become available in B.I.O.S. Library and, as mentioned earlier, samples of this equipment may be obtained by the Ministry of Supply.

The manufacture of the tape is rather more specialised. A detailed description of the method of fabrication and materials used is given in this report (Section 6 and Appendix A) but it may well be that a closer investigation on the spot will be necessary.

It appears to us that if the Magnetophon system is to be exploited to any extent in U.K., it will be highly desirable to adopt common standards for the magnetic and physical characteristics of the tape, and also for such matters as tape speed, design of tape spool centre boss and method of attaching this to the machine.

2 DESCRIPTION OF SYSTEM

As has been mentioned in Section 1, some types of Magnetophon employ the D.C. method for wiping and biassing whereas others use A.C. The D.C. method, in which the recording medium is magnetised to saturation by the

D.C. in the wiping head and is subsequently brougnt to a "working point" on the linear portion of the B/H curve by the D.C. in the recording head, is well-known and it is not proposed to describe it further here. A detailed discussion is to be found in the Journal of the Institution of Electrical Engineers, Vol.82 No.495 dated March 1938 in a paper by A.E.Barrett and C.J.F.Tweed entitled "Some Aspects of Magnetic Recording and its Application to Broadcasting".

The use of A.C. for wiping and biassing is a newer development, references to which are to be found in items (4), (5) and (7) of Section 8. A brief description of this method as used in the Magnetophon follows, and relates in particular to type HTS which is a high-quality model for recording and reproduction.

The head assembly is shown in fig.10 from which it will be seen that the wiping, recording and reproducing heads are mounted side by side. The tape passes the wiping, recording and reproducing heads, in that order, at a speed of 77 cm/sec. The heads are all approximately similar in that they are annular in shape and are made of laminated permeable metal. Each comprises two symmetrical parts, each part carrying half the turns. Each has a gap in the part of the surface in contact with the tape, the gaps being 0.5, 0.045 and 0.02 mm. for the wiping, recording and reproducing heads respectively.

Wiping current at 35 to 40 kc/s is fed to the wiping head and biassing current at 80 to 100 kc/s is fed to the recording head. The audio frequency currents fed to the recording head are superimposed upon, and do not modulate, the biassing current.

Consider now a particle of the tape as it passes the wiping head. Across the gap of the wiping head is set up a magnetic field with a maximum in the middle of the gap and falling rapidly away on both sides. A magnetic particle passing across will undergo, owing to the alternating nature of the field, a continually reversing magnetisation, first in a steadily increasing field and, after the middle of the gap, in a steadily decreasing one (see lower part of fig.1). By a suitable choice of the frequency of the wiping current in relation to the speed of the tape and to the width of the gap it is possible to ensure that at some point of its journey

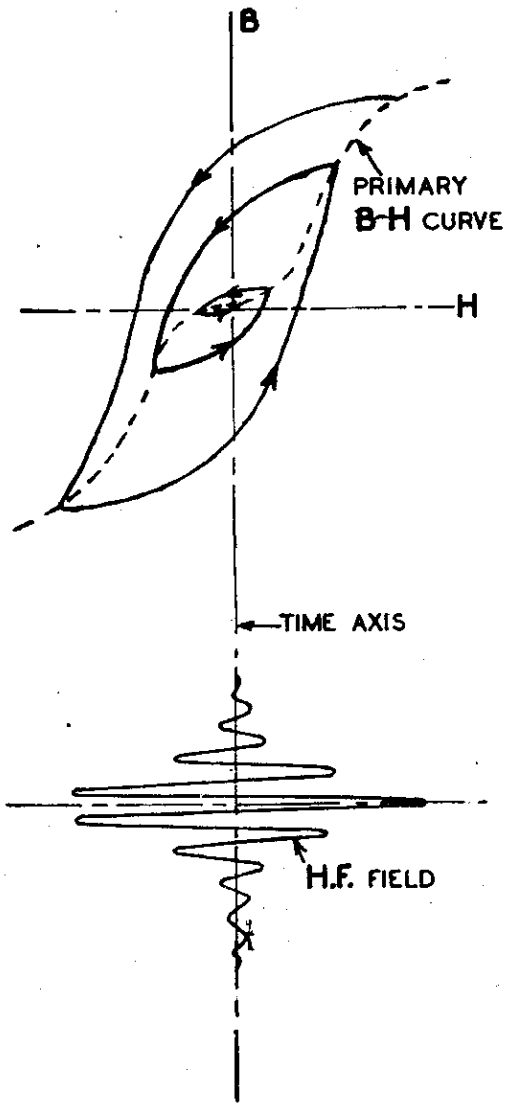

B
PRIMARY
B-H CURVE
H
TIME AXIS
H.F. FIELD

FIG.1.

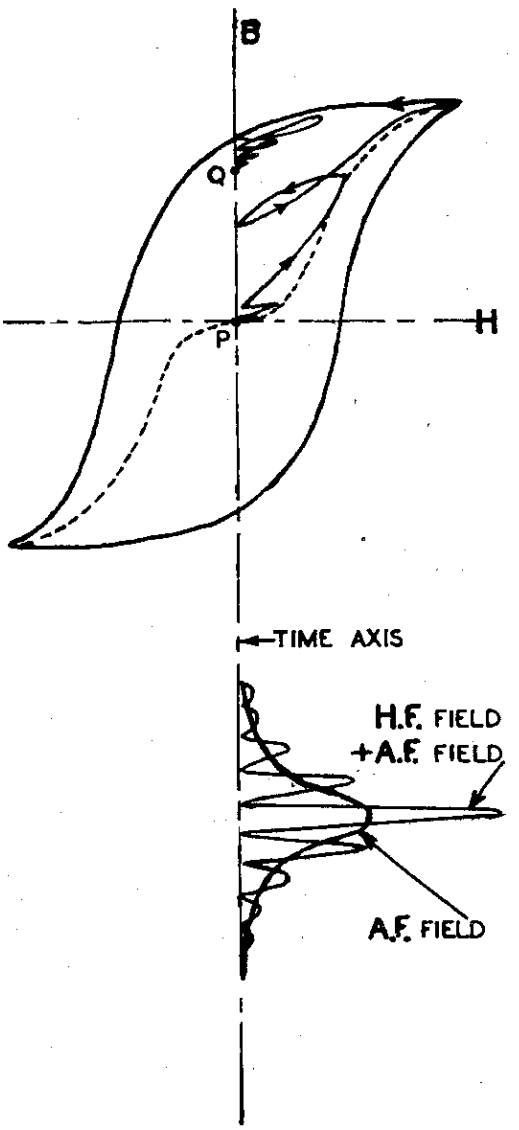

B
Q
P
H
TIME AXIS
H.F. FIELD
+A.F. FIELD
A.F. FIELD

FIG.2.

across the gap the particle is magnetised to saturation, thus ensuring that the effect of any previous magnetisation is obliterated. In the upper part of fig.1 the process is traced out (for the sake of clarity, only the decreasing field is shown). As the particle enters the field, ever increasing hysteresis curves are described until, at the middle of the gap, saturation conditions are reached. After this the particle follows continuously decreasing hysteresis curves to the origin. The recording medium thus leaves the wiping head in a completely demagnetised, i.e. non-magnetic, state.

The particle now approaches the recording head. Suppose first of all that no audio frequency current is flowing in the recording head. The effect of the biassing current will be very similar to that of the wiping current in the wiping head and the tape will consequently leave the recording head in a completely demagnetised state. Such a non-magnetic medium should not induce background noise in the reproducing head.

If now there is superimposed on the biassing current a sinusoidal audio-frequency current of the same amplitude, the field experienced by the particle during its passage past the recording head gap will take the form shown in the lower portion of fig.2 (H.F.field + A.F.field). During the comparatively short time that the particle takes to pass the gap, the audio-frequency field is assumed to be constant and for the purpose of fig.2 is taken at its peak value. Owing to the asymmetrical nature of the curve about the X-axis, the particle now does not leave the field in a demagnetised state, but with a certain remanent magnetisation. In the upper portion of fig.2 are traced out the corresponding hysteresis curves from the time the particle enters the field of the recording head in a demagnetised state (point P) until the time when it leaves the field (point Q). The remanent magnetisation, of which the length PQ is a measure, is closely proportional to the instantaneous value of the audio-frequency current in the recording head over a wide range of amplitudes and it is upon this fact that the success of the A.C. biassing system largely depends.

The initial magnetisation of a ferro-magnetic material takes place according to the primary B-H curve. This curve is characterised by its non-linearity near the origin and, after a comparatively short linear portion, its deflection into the saturation curve.

This curve as it stands, cannot be used for recording purposes owing to its marked non-linearity. The use of an alternating current for biassing can be considered as having the effect of linearising the primary curve to such an extent that it is possible to record from the origin with small harmonic distortion. A most important factor is the magnitude of the biassing current. The optimum value is that corresponding to a point at the top of the linear portion of the primary B-H curve.

The assumption of constancy of the audio-frequency field during the time taken for a particle to pass through it, though justified in the case of low audio-frequencies, is no longer entirely true when the frequency is high, say in the neighbourhood of 10,000 c/s. At such frequencies there may be a noticeable change in phase and therefore in amplitude during the time the particle is passing through the field. This results in a reduction of the degree of remanent magnetisation produced by frequencies of this order as compared with low audio-frequencies of the same amplitude. To compensate for this it is usual to insert corrector circuits in the recording amplifier in order to pre-emphasise progressively the higher audio-frequencies before they reach the recording head.

Consider now the effect of the tape on the reproducing head. If no audio-frequency has been present in the recording head, the tape will, as stated above, be completely demagnetised and thus will induce no e.m.f's in the reproducing head coils. Any recorded audio frequency will, however, set up corresponding e.m.f's in the coils. The only qualification of this statement relates again to the higher audio-frequencies, the recorded wavelength of which becomes comparable with the gap width. At 10,000 c/s, for example, the gap width is approximately a quarter of the recorded wavelength. This results in the induced e.m.f. being less than it would be for the same modulation amplitude at a much lower frequency, say 100 c/s. The progressive attenuation of the higher audio-frequencies due to this factor is compensated for by correction circuits in the reproducing amplifier and there results a substantially flat overall frequency characteristic between the input of the recording amplifier and the output of the reproducing amplifier up to approximately 10,000 c/s.

The chief merit claimed for the A.C.wiping and biassing method is the considerable reduction in background noise, by virtue of which it is possible, whilst restricting the peak amplitude of the recording signal to a value for which the harmonic content is less than 4%, to improve the signal/noise ratio to a point at which the noise is unobjectionable even in the quieter musical passages. It is claimed for the HTS model, using type L tape, that the ratio of peak signal to background noise, when measured with the interposition of an aural sensitivity network, is 55 db.

Dr.von Braunmühl has stated that the full advantages of the A.C.wiping and biassing method in reducing background noise cannot be realised with a metallic recording medium. According to him it is necessary that the medium should consist of discrete particles such as are used in the composition of the Magnetophon tape. It is further claimed that there is merit in reducing the thickness of the magnetisable layer, as has been done in the type LG tape.

3 APPLICATIONS

The uses to which the system has been put in Germany and elsewhere are as follows:-

(1) office dictating and transcribing machine (type FT3 and Tonschreiber f)

(2) (Wehrmacht) recording of high-speed telegraph signals: reproducing these at a slower speed with facilities for restoration of original pitch (Tonschreiber b)

(3) Monitoring telephone conversations (Tonschreiber b and A 1000 L 40)

(4) (Wehrmacht & RRG) recording and reproduction of speech - reportage etc. - in circumstances where some sacrifice of quality is permissible in the interests of extreme portability of the apparatus, ease of operation and ability to operate without mains supply (Tonschreiber c and K.26)

(5) (German Navy) recording and reproduction of speech from intercommunication telephone system on board ship, etc. (Tonschreiber A 1000 L 40, also known as RE3)

(6) (Wehrmacht & RRG) recording and reproduction of speech - reportage etc. - in circumstances where mains supply is not available but portability e.g. in a Volkswagen or Jeep is required, together with quality suitable for broadcasting (Tonschreiber d)

(7) (RRG) recording and reproduction of speech and music for broadcasting (type K4)

(8) (RRG) recording and reproduction of speech and music for broadcasting, when the highest standards of quality have to be met (types HTS and K7)

The following uses and applications are either in process of development or have been considered:-

(9) in film studio technique for a variety of purposes e.g. rehearsal, sound injection and in the limit for all recording up to the stage when sound and picture have to be married.

(10) for stereophonic recording and reproduction, by recording two side-by-side tracks on the same tape

(11) for sale to the public, either as part of a radio receiver or separately, using cassette loading

(12) for recording on a sheet, instead of on a tape, so that the recording can be sent by letter post.

4 HISTORY OF DEVELOPMENT

The Magnetophon in its original form was developed and marketed by AEG of Berlin several years before the war, primarily as a dictating machine and was provided with the facilities necessary for that purpose. The tape was developed and produced by I.G.Farbenindustrie at Ludwigshafen, the development work dating back to 1928.

The basic advantages of the method were appreciated by the RRG who themselves undertook some development work with the object of adapting the method to the requirements of broadcasting. This resulted in the production in 1938/39 of type K4.

During the war a number of different types were developed by AEG for the armed forces, principal of which were Tonschreiber b, c and d and type A 1000 L 40.

At the same time, the RRG were working on the use of A.C. instead of D.C. for wiping and biassing. The successor to the type K4, known as type HTS, embodied the A.C. system and was first produced about 1942.

The HTS equipment appears to have been made in considerable quantities and was widely used in the latter part of the war in the broadcasting centres in Germany and in a number of such centres in occupied countries.

At the very end of the war a new type of tape (LG) was beginning to replace the earlier type (L) and a new model in the K4 - HTS series was about to be manufactured. This was designated K7 and contained a number of detail improvements, both in performance and ease of operation. The combination of the LG tape and K7 recorder/reproducer represents the farthest advance in the Magnetophon development to date.

5 DESCRIPTION OF EXISTING MODELS OF MAGNETOPHON EQUIPMENT

The information which it has been possible to obtain both from sources inside Germany and from investigations made in Great Britain varies considerably between one type and another. In this section some information is given about each of the following types:-

(1) FT3

(2) Tonschreiber b

(3) Tonschreiber c

(4) Tonschreiber d

(5) Tonschreiber f

(6) A 1000 L 40 (also known as RE3)

(7) R26

(8) K4

(9) HTS

(10) K7

(11) Kasettengerät

(12) Machine for recording on a quarto sheet.

The above list does not claim to be comprenensive; there may well be other types in existence about which no information has so far been obtained.

Type HTS has been singled out for more detailed treatment tnan the rest, as being a nign quality model about whicn a considerable amount is known.

(1) FT3

Purpose: For office use, as a dictating machine: recording the proceedings of meetings, conferences, trials, etc.: recording telephone conversations.

NB: NO MODEL OF THE FT3 HAS BEEN INSPECTED: THE FOLLOWING DETAILS ARE TAKEN FROM AN AEG BROCHURE ENTITLED "BESCHREIBUNG FÜR AEG-MAGNETOPHON-GERÄT MODELL FT3", A COPY OF WHICH IS AVAILABLE IN B.I.O.S. LIBRARY.

Description: The equipment consists of the following parts:- a cabinet containing the machine, a single amplifier used eitner for recording or reproduction and a loudspeaker: a control unit for the office desk: a microphone: a control unit for the typist's desk: a pair of headphones. Power requirements are 220 v., 50 c/s, 250 watts.

The machine comprises two motor-driven turntables, tape-driving motor, head assembly containing wiping, recording and reproducing heads, idler rollers, and the following controls:- main on/off switch, switch for connecting either to the desk control unit or to the typist's control unit, device for indicating how much of the tape has been used and buttons for "Quick forward run" and "Quick rewind" and "Stop".

The office desk control unit has buttons for "Engaged", "Record", "Reproduce", "Rewind" and "Stop" with appropriate indicator lamps, switches for "Microphone/telephone" and "Loudspeaker/headphones", a modulation meter and volume control. Connections are provided for microphone, headphones or loudspeaker.

The typist's desk control unit has buttons for "Reproduce" and "Rewind/stop". A control at the right-hand side changes over from loudspeaker to headphone reproduction. One on the left-hand side controls the duration of rewind when, for example, it is desired to repeat a few words.

Facilities are provided whereby several offices, each with microphone, control unit and loudspeaker and/or headphones can be connected to the same machine. As soon as the "Engaged" button in any office is operated, the "Engaged" lamps in all offices are lit.

Performance: No information available.

(2) Tonschreiber b

Purpose: For Wehrmacht use in the field: to enable high-speed telegraph signals to be recorded from the output of a receiver, and subsequently reproduced at a slower speed: facilities for restoration of pitch of the reproduced signal.

Description: The equipment is designed to operate from A.C., 230 v., 50 c/s. It is made up in three transportable units each approximately 18" x 13½" x 10". One unit contains the machine, the second the amplifiers and power supplies and the third contains tools, spares and spools of tape. All three units are in heavy-duty military-pattern cases and the first two are designed to be clamped together, the machine unit on top of the amplifier unit (see fig.3).

The Machine Unit contains the following elements (see fig.4):- motors and drive mechanism for the 2 spools; motors for driving the tape; switch which sets the machine in operation for either recording, reproducing or rewinding (7); tape speed meter (4); head assembly containing wiping, recording and reproducing heads; pitch-restoring head(11).

The Amplifier Unit contains recording amplifier, reproducing amplifier, mains unit and a nine-frequency oscillator.

The following three points are worthy of mention:-

(a) Wiping and biassing is by D.C., not A.C.

(b) Nine tape speeds are available namely:-

9,13,18,26,36,52,72,104 and 120 cm/sec.

The nine-frequency oscillator is controlled by two knobs on the front panel, one a coarse (20) and the other a fine control (21). The output of the oscillator is amplified and used to drive a synchronous motor which, in turn, drives the tape, the tape being pressed against the motor spindle during operation by a rubber idler (2). The main effort required to drive the tape is however provided by a separate motor, coupled to the shaft of the synchronous motor via a rubber idler: thus the principal function of the synchronous motor is to hold the speed of the tape constant at one of the nine speeds mentioned above.

(c) The pitch-restoring head is an ingenious device, the use of which is optional. Its purpose is to enable a recording which has been made at a high speed to be reproduced at a low speed but none the less to be reproduced at its original pitch so as to avoid loss of intelligibility which might result from the reduction in pitch corresponding to the reduction in speed. This pitch restoring head takes the form of an idler roller. When it is desired to use this the tape is looped over it and makes contact with it over about a quarter of the total circumference. In this "idler" are formed four reproducing heads, the gaps of which appear on the surface of the idler at 90° intervals around its circumference. Thus only one of these heads is in contact with the tape at any one time. This assembly is rotated by a separate motor behind the panel, the latter being operated by a control on the front of the panel (12). The speed of rotation of the head assembly is entirely

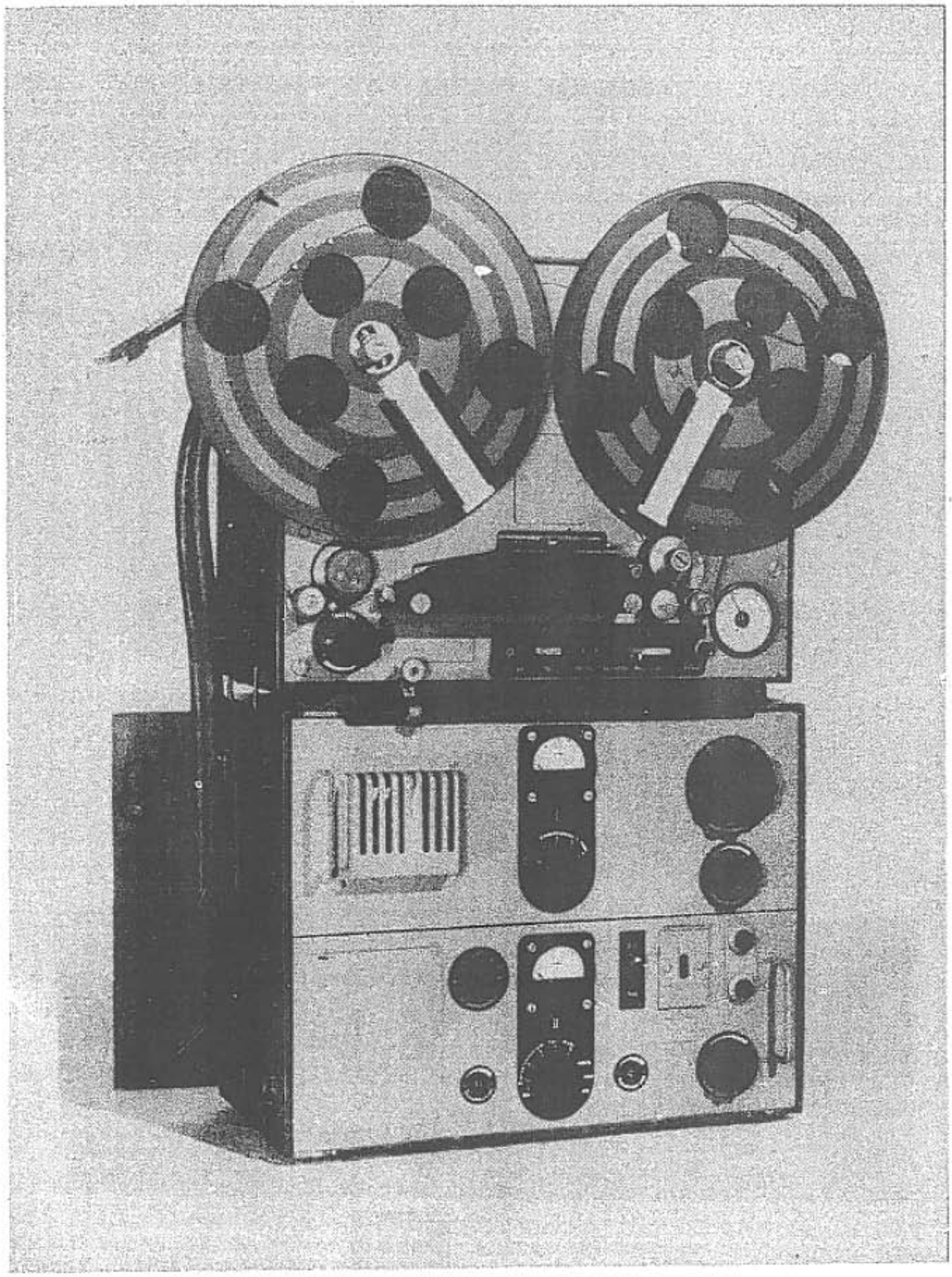


FIG.3.

Magnetophon Sound Recorder and Reproducer, Type Tonschreiber b

Complete instrument set up ready for use. The two units are clipped firmly together, the upper unit being the machine and the lower containing recording and reproducing amplifiers and 9-frequency oscillator.

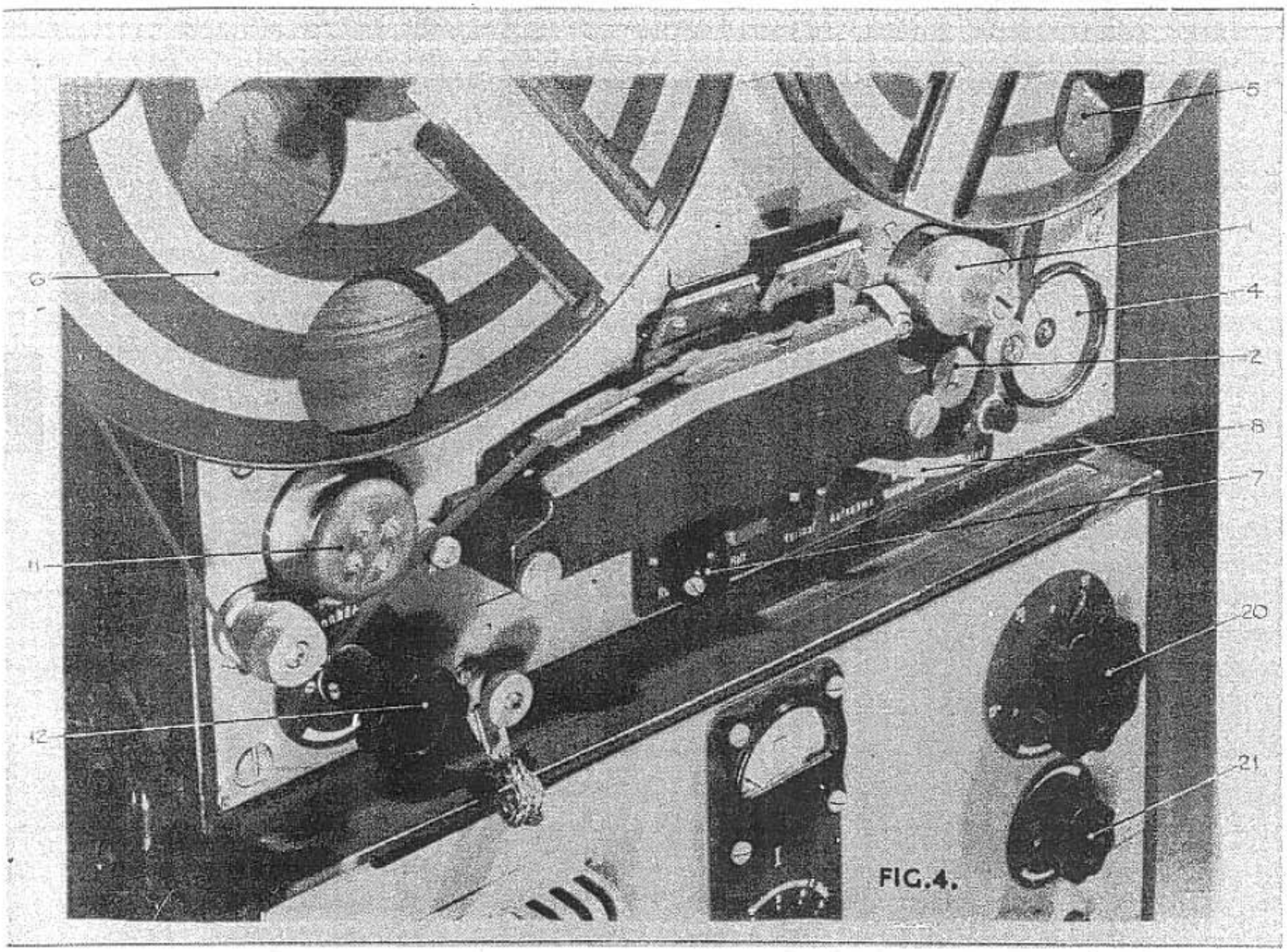


FIG.4.

FIGURE 4

Magnetophon Sound Recorder and Reproducer, Type Tonschreiber b

Details of tape driving mechanism and head assembly:-

1. tape driving spindle
2. rubber-faced idler
4. tape speed meter
5. winding reel
6. unwinding or rewinding reel
7. main control lever (forward run, rewind or stop)
8. subsidiary control lever (record or reproduce).
11. pitch restoring head
12. pitch restoring head control
20. tape speed control - coarse
21. tape speed control - fine.

independent of the tape speed. A gradual clockwise movement of the control first of all disconnects the normal reproducing head from the reproducing amplifier and substitutes in its place the commutated output from the pitch-restoring head whereby at any instant the reproducing amplifier receives the output from that one of the four heads which is in contact with the tape. Further movement of the control gradually speeds up the motor and causes the four reproducing heads to "scan" the tape at a gradually increasing speed. As the speed of the scanning increases so does the apparent pitch. It is interesting to note that the reproduced modulation consists of an integration of short-period "scans" by each of the four heads in turn and that this scanning takes place backwards, i.e. the relative motion of heads and tape is opposite to that which normally occurs during reproduction.

The speed of rewinding is such as to enable the tape to be rewound at considerably less than the time taken for forward running even at 120 cm/sec.

Performance: At all speeds the response in the lower register falls off sharply below 250 c/s. This is no doubt intentional, as bass-cut circuits are found in both recording and reproducing amplifiers. A tape speed of 104 cm/sec. gives a level response between 250 and 7,000 c/s but high frequency response falls off badly at all speeds below 72 cm/sec.

(3) Tonschreiber c

Purpose: For recording telegraph signals or speech under conditions in which lightness of weight and compactness are the prime considerations: for use where mains supply is unlikely to be available: for purposes in which the recording and reproducing instruments can be separate.

Description: There are two separate units, one a recorder and the other a reproducer. Each of these consists of two separate parts, normally clipped together, as follows:-

Recorder	) Reproducer)
Compartment for reels of tape	) Battery compartment)

The intention is that the recorder shall be used "in the field", tapes recorded thereon being taken back to base to be replayed on the reproducer.

Both units are in military type containers, each 17¼" high, 14½" wide and 8¾" deep. The recorder weighs 58 lbs. and the reproducer 51 lbs. so that each unit is capable of being carried by one man, either on the back or, sub-divided, by hand.

The recorder is adapted to record either from a receiver output or from a microphone which is incorporated. The tape speed is 18 cm/sec., at which speed there is a serious reduction in response at the higher audio-frequencies as compared with the "standard" tape speed of 77 cm/sec. A smaller tape than normal is used, having a playing time of about 12 minutes.

The recorder is driven by a spring motor which can be wound while the machine is in operation: a bell rings as soon as the spring is half unwound. This unit has neither wiping nor reproducing heads, it being assumed that only tape which has been previously wiped will be used. D.C. biassing current in the recording head is provided by a 4½ v. dry battery, this also providing current for the carbon microphone. There is no amplifier, the receiver or microphone output being fed to the recording head via a simple filter network. There is no means of monitoring the signal being recorded, either visually or aurally.

The reproducer contains both wiping and reproducing heads. A two-position control causes the tape to run either forward or backward. In the forward running position, the output of the reproducing head is fed to an amplifier and thence to headphone sockets. In the other position, the tape runs back at a much higher speed. There is a further control which interlocks with the main control and when this is operated D.C. is supplied to the wiping head and the tape is wiped during the rewinding process. A tape on being received from the recorder unit must first of all be rewound. After being played through, the normal procedure would no doubt be to wipe on the second rewind.

The batteries consist of a 12 v. accumulator and a 90 v. dry battery. The motor is a D.C. commutator motor driven by the 12 v. battery. A conventional 3-stage amplifier is used, all three valves being type RV 12P2000. It includes a certain amount of frequency correction. Its heater supply is derived from the accumulator and its H.T. supply from the dry battery. The accumulator also supplies current to the wiping head.

Performance: Speech quality is not good, due no doubt to the low tape speed. It seems likely howeve that the equipment is intended principally for the recording of morse signals.

(4) Tonschreiber d

Purpose: For the use of reporters, War Correspondents etc. for use in conditions where a mains supply is unlikely to be available: commonly installed in a vehicle.

Description: The design is evidently a development of the Tonschreiber b. In the case of two models inspected, this consisted of two units mounted together in a metal frame, the whole having been installed in a Volkswagen.

The left-hand unit contains machine and reproducing amplifier whilst the right-hand unit contains recording amplifier, microphone mixer, level indicating meter and cueing arrangements apparently intended for communication with a commentator who may be at some distance from the equipment.

The general construction of the machine is along the same lines as the Tonschreiber b. Battery supplies for the left-hand unit are derived from a 12 volt accumulator, H.T. supply for the reproducing amplifier being provided by a vibrator fed from the accumulator. The consumption is 3 amps. for the machine and .45 amps. for the amplifier. The tape speed is approximately 77 cm/sec., the speed of the motor being controlled by a centrifugal interrupter mounted as a unit on the end of the motor shaft. A pilot lamp on the front panel receives a voltage from the interrupter and flickers when the correct speed is obtained. Both wiping and biassing are by D.C., pre-set controls being provided for these at the rear of the machine.

The recording amplifier in the right-hand unit has inputs suitable for moving coil, crystal or carbon microphones. The moving coil and crystal inputs each have a single pre-amplifier and matching unit, feeding into separate potentiometers and thence into a three-stage amplifier, all the valves of which are type RV2, 4P700. Headphone and output terminals are provided. The unit is operated from a 180 v. dry H.T. battery and a 2.4 v. alkaline L.T. accumulator. H.T. consumption is 6 mA, and L.T. 300 mA.

Performance: The frequency response was found to be level ± 4 db between 50 and 7,000 c/s. There is a gradual rise of 4 db between 50 and 1,000 c/s, with a further rise of 4 db to 5,000 c/s above which the response falls away rapidly.

(5) Tonschreiber f

See FD 1186/47.

One model only of this has been very cursorily inspected. It is evidently intended as a dictating machine and in this sense is a successor to the FT3. It uses A.C. for wiping and biassing.

(6) A1000 L40 (also known as RE3)

Purpose: Used by the Germany Navy for recording and reproduction of speech from communication telephone systems on board ship, etc.

Description: A single mechanical assembly consisting of machine, recording amplifier, reproducing amplifier and controls is mounted in a wooden framework. The main panel is horizontal. The equipment is designed to operate from A.C. 230 v. 50 c/s. The recording speed is 77 cm/sec. but the speed of reproduction is continuously variable up to a maximum of 100 cm/sec. Both wiping and biassing currents are D.C.

Operation of the machine is controlled by four press-buttons at the front of the panel, labelled respectively "REWIND", "RECORD", "REPRODUCE" and "STOP". Three A.C/D.C. commutator motors are used, one driving each of the two turntables and the third driving the tape. The latter also drives a fan for cooling all three motors.

Two automatic trips are provided when recording only. The first, to stop the machine when the supply spool is empty, is actuated by an arm pressing on the outside of the reel: this arm also operates an indicator showing what length of tape has been unwound. The second, which depends on the insulation provided by the tape between a pulley and a spring arm, stops the machine in the event of a tape breakage.

The recording and reproducing amplifiers are in one unit which is detachable from the main frame.

Performance: The speed constancy is satisfactory for speech but barely good enough for recording and reproducing music. The overall frequency response is level ± 3 db between 50 and 7,000 c/s. There is a rise of 4 db between 50 and 200 c/s: thereafter response is level to 1,000 c/s with a rise of 2 db to 4,000 c/s, above which frequency there is a rapid fall off.

(7) R26

Purpose: For "front line" reporting by broadcasting and other commentators: for use in conditions where minimum weight and operation by batteries are essential.

Description: The equipment consists of three units: the first contains the machine, recording and reproducing amplifiers and oscillators; the second contains a 12 v. accumulator and a 90 v. dry battery, microphone and spares; the third contains 36 reels of tape. The two principal units weigh 33 and 50 lbs respectively and can be clipped together if desired. The whole equipment is designed to be carried by two men.

The machine is driven by a spring motor. The speed of the tape is approximately 25 cm/sec. and the standard reel of tape used in this equipment gives a recording time of 10 - 15 mins. A.C. is used for biassing but no facilities are provided for automatically wiping the tape before it reaches the recording head. It is assumed that all tape used will have been previously wiped with A.C. and a coil suitable for connection directly to 230 v. 50 c/s., A.C. mains is provided so that any necessary wiping may be carried out on the machine itself "at base".

Performance: Speed constancy is good enough for speech but not for music. The frequency response range is from about 50 to 5,500 c/s.

(8) K4 (RRG designation R24)

Purpose: For high quality recording and reproduction for broadcasting: for use in conditions where transportable equipment is desirable but mains supply is available: for use in conjunction with another similar machine for the recording and reproduction of continuous programmes of long duration.

NB: NO SAMPLE OF THIS MODEL HAS BEEN EXAMINED IN U.K. FOR THE PURPOSE OF THIS REPORT: THE FOLLOWING INFORMATION IS DERIVED FROM WRITTEN MATTER PARTLY FROM AEG AND PARTLY FROM RRG.

Description: The equipment is mounted as a complete unit in a carrying case which contains the machine, recording equaliser, reproducing equaliser-amplifier and mains unit. The overall dimensions are 18½" x 18½" x 12½" and the weight is 123 lbs. The equipment is designed to operate from A.C. 230 v. 50 c/s, power consumption being 300 watts. D.C. wiping and biassing are used.

The machine unit contains three motors. Two of these drive the turntables and are series commutator motors. The third, a split-phase motor, drives the tape at a constant speed of 77 cm/sec. both when recording and when reproducing. All these motors are fitted with magnetically operated band brakes which ensure rapid deceleration when the STOP button is pressed.

D.C. both for wiping and biassing is derived from the mains unit. The value of biassing current is indicated on a meter mounted on the front panel. An adjacent potentiometer with screwdriver adjustment enables the biassing current to be adjusted to the required value.

Operation is by means of four push-buttons labelled respectively "REWIND", "RECORD", "REPRODUCE" and "STOP". The rewind speed is approximately four times the normal forward running speed and the tape can be made to travel at high speed in the forward direction by simultaneous operation of the "REWIND" and "STOP" buttons.

When using two machines for a recording of longer duration than one reel, it is usual to start the second machine a minute or so before the end of the tape on the first machine. In this way identical modulation appears for about one minute at the end of reel 1 and at the beginning of reel 2 and similarly for reels two and three and so on. In order to join up successive reels when reproducing, a method commonly employed is to use a pair of headphones in which the individual earphones are split, each being fed from one machine. The second machine is started up during the minute's overlap so as to be slightly ahead of the first machine and the two are brought into step, as judged by earphones, by pressing the "SYNCHRONISE" button on machine 2, this button having the effect of slightly slowing down the tape driving motor of that machine. As soon as synchronisation has been effected, the reproduction circuit is switched from machine 1 to machine 2, whereupon reel 1 is stopped, rewound at high speed, and replaced by reel 3 and so on.

The input impedance of the recording equaliser is approximately 200 ohms as is also the output impedance of the reproducing amplifier.

Performance: No information available.

(9) HTS (RRG designation R122a)

Purpose: For high quality recording and reproduction of speech and music for broadcasting: for use under conditions in which the equipment is to be permanently installed: for use in conjunction with another similar machine for the recording and reproduction of continuous programmes of long duration.

Description: The equipment consists of the following units:-

(a) Machine unit, incorporating -
(b) Head assembly, type HTS (RRG designation R7a)
(c) Recording amplifier V7b.
(d) Reproducing amplifier V5.
(e) Mains unit N7b.

Fig.5 shows the units assembled in a rough cabinet. For broadcasting purposes, a complete installation will normally consist of two such equipments together

with ancilliary apparatus such as microphone amplifiers, programme meter, monitoring amplifier, loudspeaker, control panel, meter panel and jackfield.

(a) Machine Unit: Figs. 6, 7 and 8 are three views of the machine unit. Fig.9 is the wiring diagram (it should be noted however that the order in which the terminals are shown in the diagram does not correspond with the order in which they are mounted on the apparatus).

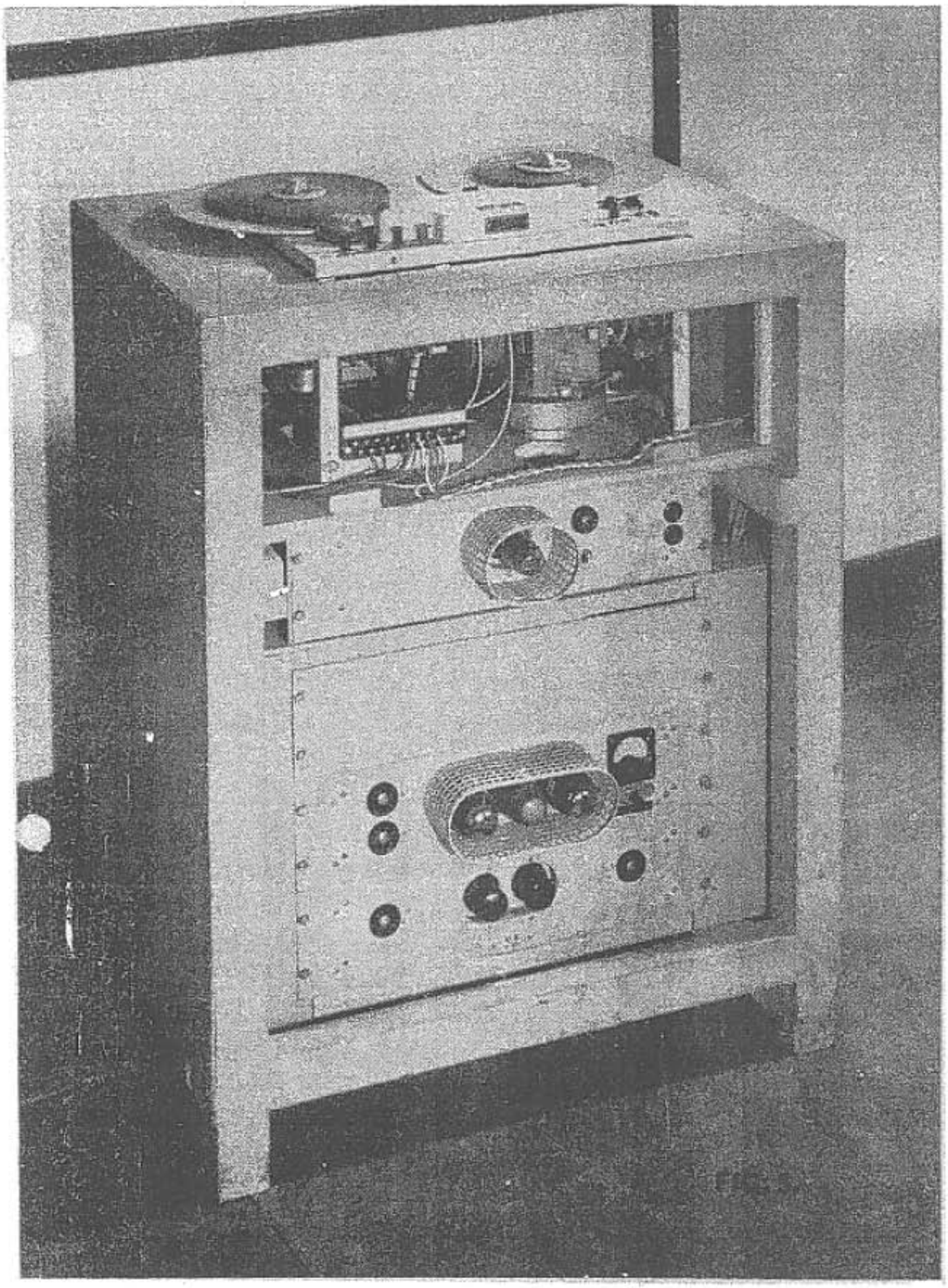
On the upper side of the motor board are the tape winding plates, tape guides, head assembly and control buttons. On the under side are three motors and the contacts operated by the control buttons.

The two tape winding plates are driven by separate A.C. motors for forward running and for rewinding. These motors are series wound, to make the tension of the tape more or less independent of the reel diameter. To prevent the motors from running away when the reel is empty, centrifugal brakes are fitted at the lower end of the spindles. The maximum speed is about 800 r.p.m. The third motor is the main drive motor. This is a powerful governed induction motor with a speed of 1460/1480 r.p.m. which drives the tape at a uniform speed of 77 cm/sec.

The motor associated with the unwinding plate exerts a pull in the opposite direction to the main drive motor, thus keeping the tape taut; at the same time, the motor driving the other plate tends to drive this, at all reel diameters, at such a speed as to maintain in tension the tape between it and the spindle of the main drive motor.

Rewinding takes place at about 7 times the forward running speed; in this case the main drive motor, although running, takes no part in the operation as the rubber-faced pressure roller (see fig.6) is not engaged.

Rapid forward running can be acnieved by pressing the "REWIND" and "STOP" buttons simultaneously. For rapid forward running or rewinding the centrifugal brakes of the motor concerned are rendered inoperative by an interposed



Magnetophon Sound Recorder and Reproducer, Type HTS

General view, showing machine, mains unit (N7b), recording amplifier (V7b) and reproducing amplifier (V5) mounted in rough cabinet.

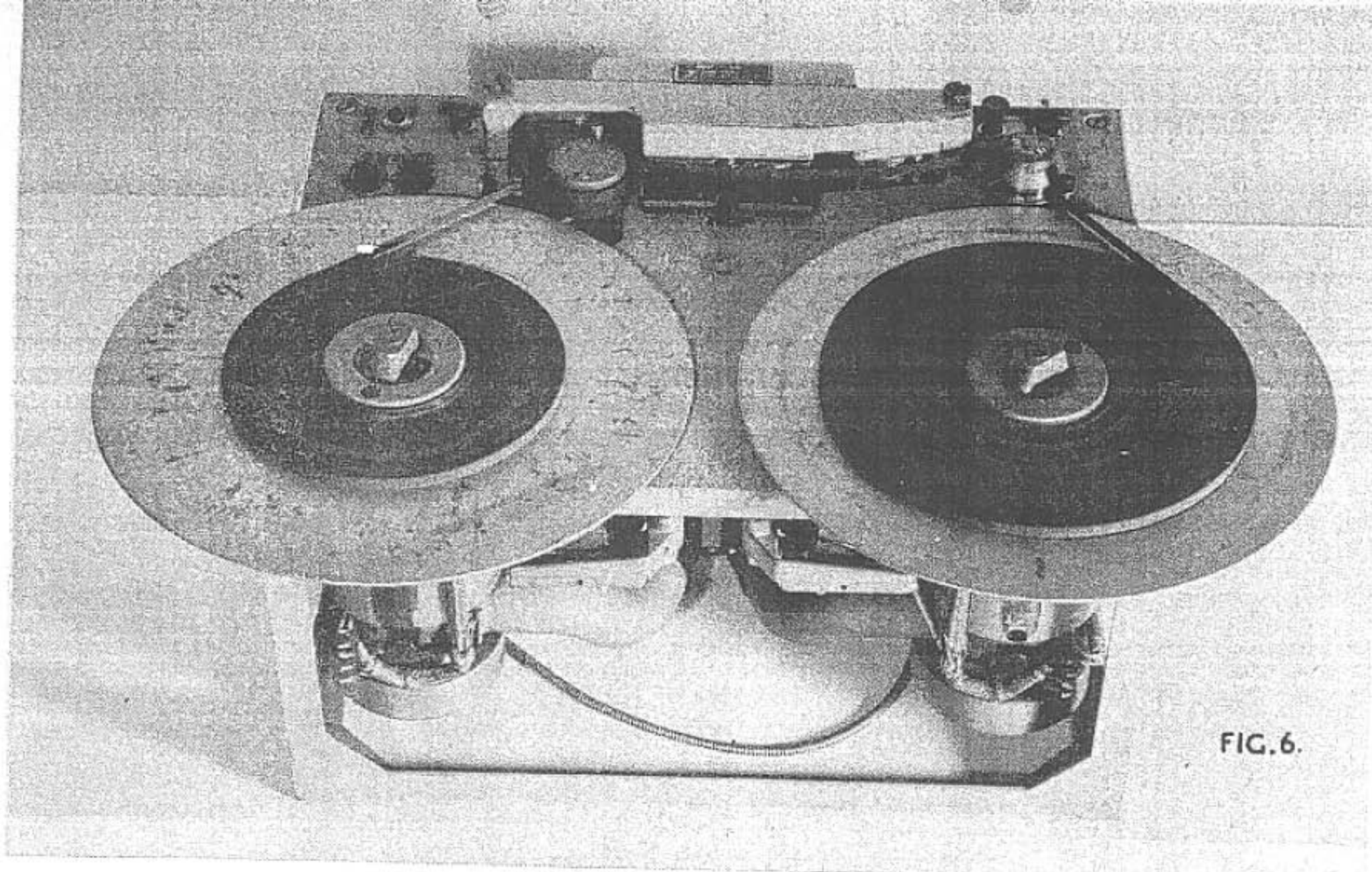


FIG. 6.

FIGURE 6

Magnetophon Sound Recorder and Reproducer, Type HTS

Machine, from rear. This shows the tape passing from the "REWIND" turntable (right) past a spring-controlled guide and round an idler pulley to the head assembly. The latter can be withdrawn from the machine plate by removing the two slotted screws at either end. The tape passes in succession the wiping, recording and reproducing heads (the hinged plate covering the two latter is here seen open). It then passes between the spindle (the top of which can be seen) of the main drive motor and a rubber-faced pressure roller, past another spring-controlled guide to the "WIND" turntable. Top left can be seen the mains switch and two fuses, also a button which slows down the tape during reproduction: this is used with a 2-machine installation to bring the two machines into step during the overlap period of two successive reels of a multi-reel programme. Top right can be seen two of the four operating buttons. From right to left, these are the "REWIND" (shown operated), "RECORD" and (hidden from view) "REPRODUCE" and "STOP".

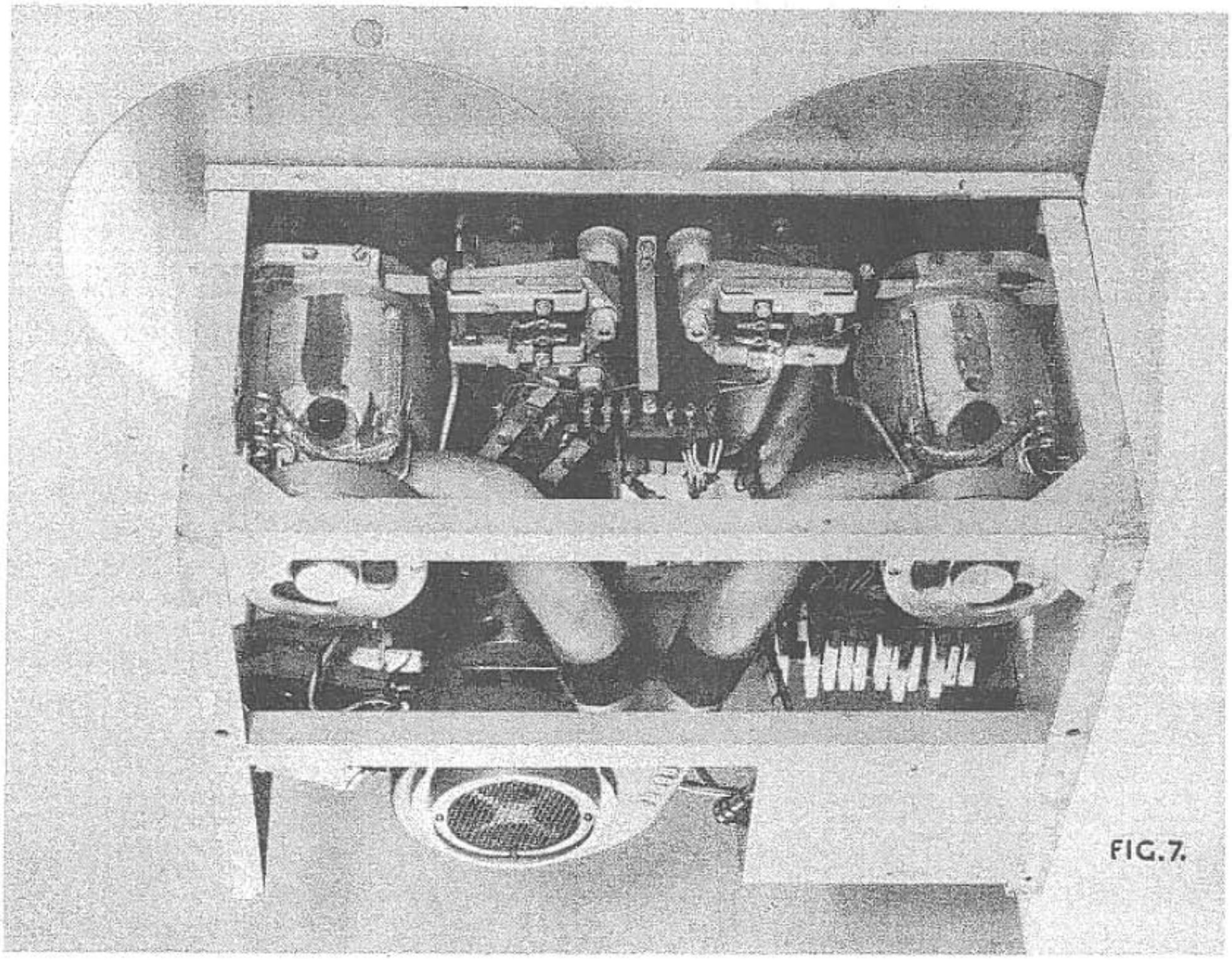


FIGURE 7

Magnetophon Sound Recorder and Reproducer, Type HTS

Machine unit: rear view from below. The turntable driving motors ("WIND" left and "REWIND" right) are seen and between them the solenoids operating the band brakes. Below the left-hand of these is a third similar solenoid which operates the rubber-faced pressure roller, pressing it against the spindle of the main drive motor when either "RECORD" or "REPRODUCE" button is pressed. Towards the bottom on the right can be seen the leaf contacts which are operated by the push-button controls. The layout of the cooling system is also clearly seen.

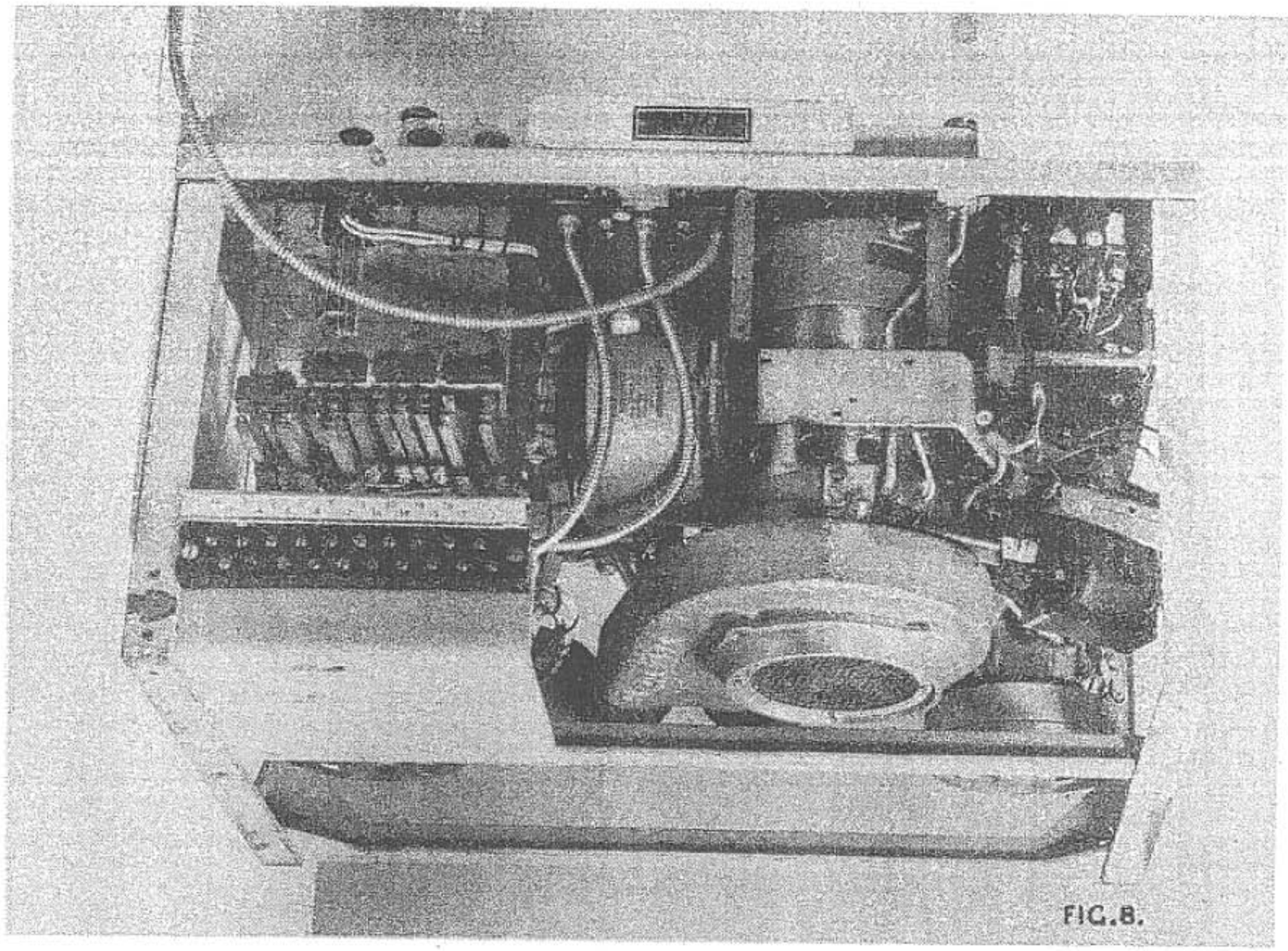


FIGURE 8

Magnetophon Sound Recorder and Reproducer, Type HTS

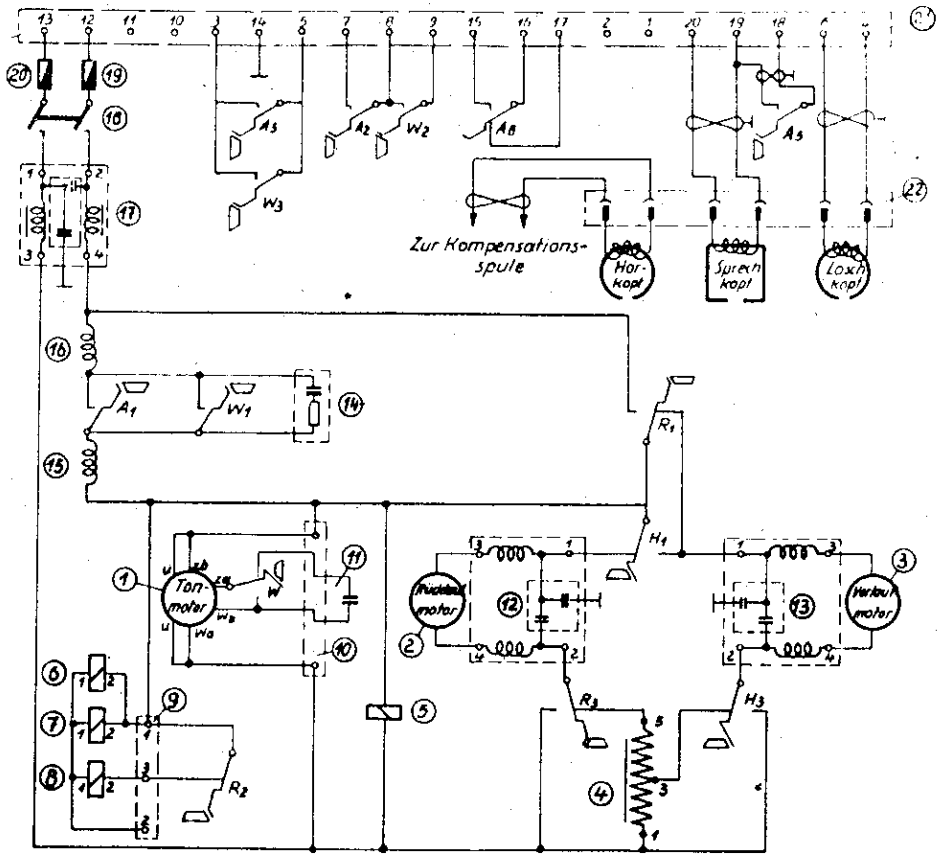
Machine unit: front view from below. Above the base plate is the head assembly (R7a is the RRG type No.) On the left, above the terminal block, is the control mechanism operated by buttons above the base plate (the left-hand button, "REWIND", is shown operated). The main drive motor is clearly seen, a screening plate having been removed for this purpose. At the base of the motor is a fan which provides a stream of cooling air for all three motors. To the right of this and slightly above is the solenoid which operates a band brake on the main drive motor.

12.11.42 Hgs

12 und 13 - Netz 220 Volt ~
15, 16 u. 17 = c, b, a Leitung
18 u. 20 = Sprechkopfzuführung
4 u. 6 = Löschkopfzuführung
Kontakt 48 muß zeitlich vor A5 schalten

Laufwerkschaltung

Stck	Benennung	AEG Bestell Nr	Teil
1	Buchsenleiste	B 409690	22
1	Anschlußleiste	B 403504	21
1	Sicherung	E 407482	20
1	Sicherung	E 407482	19
1	Schalter	E 402965	18
1	Störschutz	R 551450	17
1	Drosselspule	B 402860	16
1	Drosselspule	B 402860	15
1	Störschutzkondensator 0,5µF 50Ω	E 405360	14
1	Störschutz	B 407726	13
1	Störschutz	B 407767	12
1	Kondensator 2µF 430 V	B 406681	11
1	Anschlußleiste	B 402931	10
1	Anschlußleiste	B 403865	9
1	Rollenmagnet	B 402240	8
1	Rücklaufmotorbremsmagnet	B 402240	7
1	Vorlaufmotorbremsmagnet	B 402240	6
1	Tonmotorbremsmagnet	B 402240	5
1	Vorschalldrossel	E 407485	4
1	Vorlaufmotor	E 410719	3
1	Rücklaufmotor	E 410720	2
1	Tonmotor	E 410275	1



R Rücklauf	A Aufnahme	W Wiedergabe	H Halt	Kontaktanordnung Kontakte von vorne gesehen	V Verzögerung
W R W	A A A	A A A	W - W	1 2 3 / 4 5 6 / 8	W
- - -	- A -	- - -	- - -		
	W				

A = Arbeitskontakt, R = Ruhekontakt, W = Wechselkontakt.

FIG. 9.

AIR22a/1
1. Dezember 1942.

18.11.42 Hgs

free-wheel. If this free-wheel were not fitted, a small reel, at the rapid rate, would be endangered as soon as the diameter of the unwinding reel became less than the diameter of the winding reel; if the centrifugal brakes came into play at this point (as they would but for the free-wheel) the tape would snap.

In order to bring the tape to rest quickly when the "STOP" button is pressed, the motors are fitted with band brakes. Whilst the apparatus is in motion the bands are held away from the brake drums by relays. When the "STOP" button is pressed, the magnets are disconnected and the brakes bring the motors to rest rapidly.

To the lower end of the main drive motor spindle is attached a blower for cooling this and the other two motors; the air current is led through tubes which are clearly visible in fig.7. Fresh air is drawn in via an acoustically damped chamber from a hole at the bottom of the cabinet. The warm air is blown out through a slit in the back of the cabinet.

The machine operates from 220 v. 50 c/s, the maximum power consumption being 250 VA. A 4-amp fuse is included in each conductor, these being situated on the right-hand side of the motor-board. The complete assembly is earthed via an earth terminal at the back of the cabinet.

Dimensions:	
With winding plates in position:	24½" x 15½"
" " " removed:	17½" x 12½"
Overall height	11"
Weight:	66 lbs.

(b) Head Assembly type HTS (RRG designation R7a): This is shown in Fig.10. The heads from left to right (the order in which they are passed by the tape), are:-

Wiping Head
Recording Head
Reproducing Head

These three heads are housed in an oblong

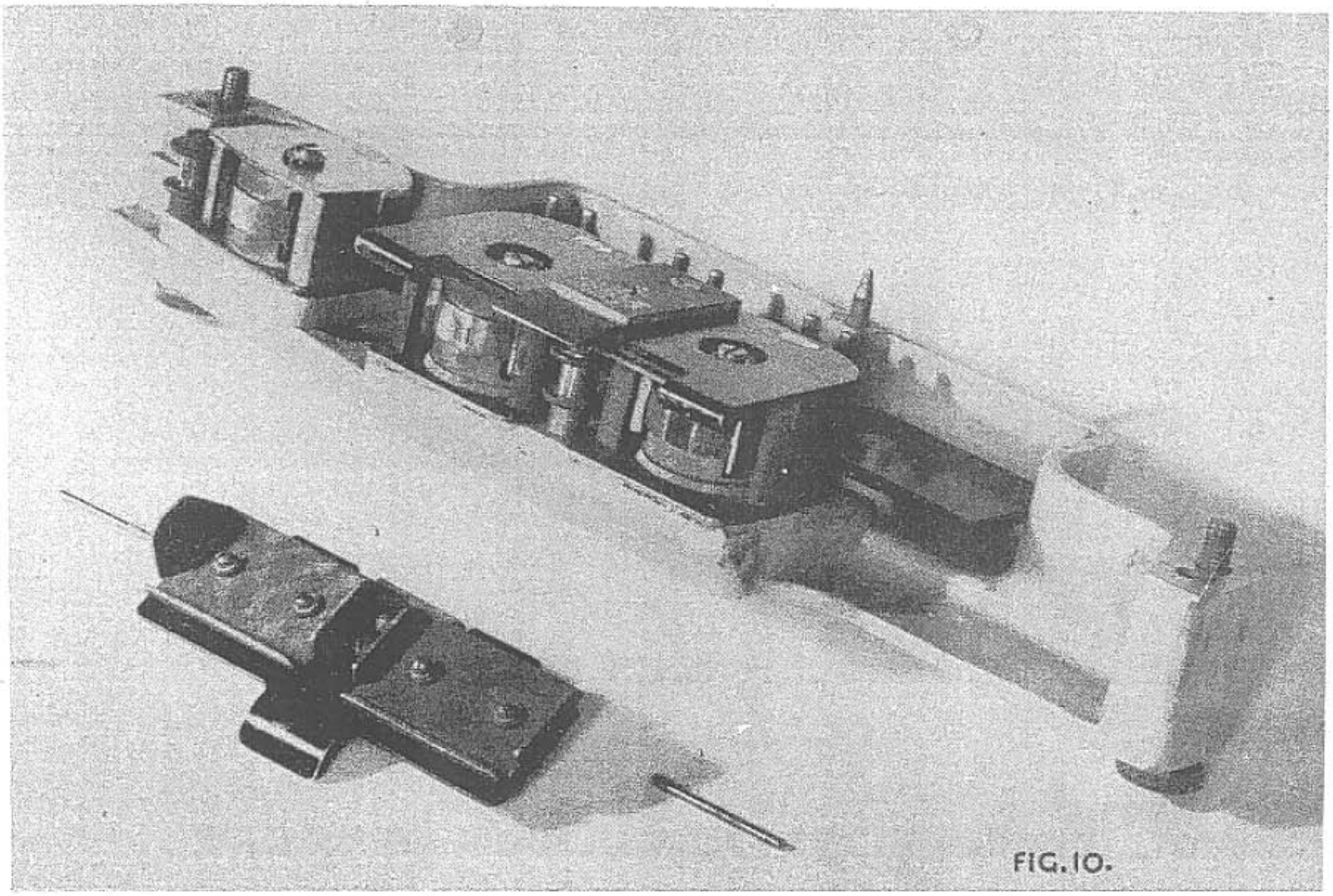


FIGURE 10

Magnetophon Sound Recorder and Reproducer, Type HTS

Head assembly, inverted and with cover plate, screening recording and reproducing heads during operation, removed. The heads are respectively (l. to r.) wiping, recording and reproducing. Two tape guides can be seen, one to the left of the wiping head and the other between recording and reproducing heads. Electrical connections to the heads are made by means of the pins seen behind the recording and reproducing heads.

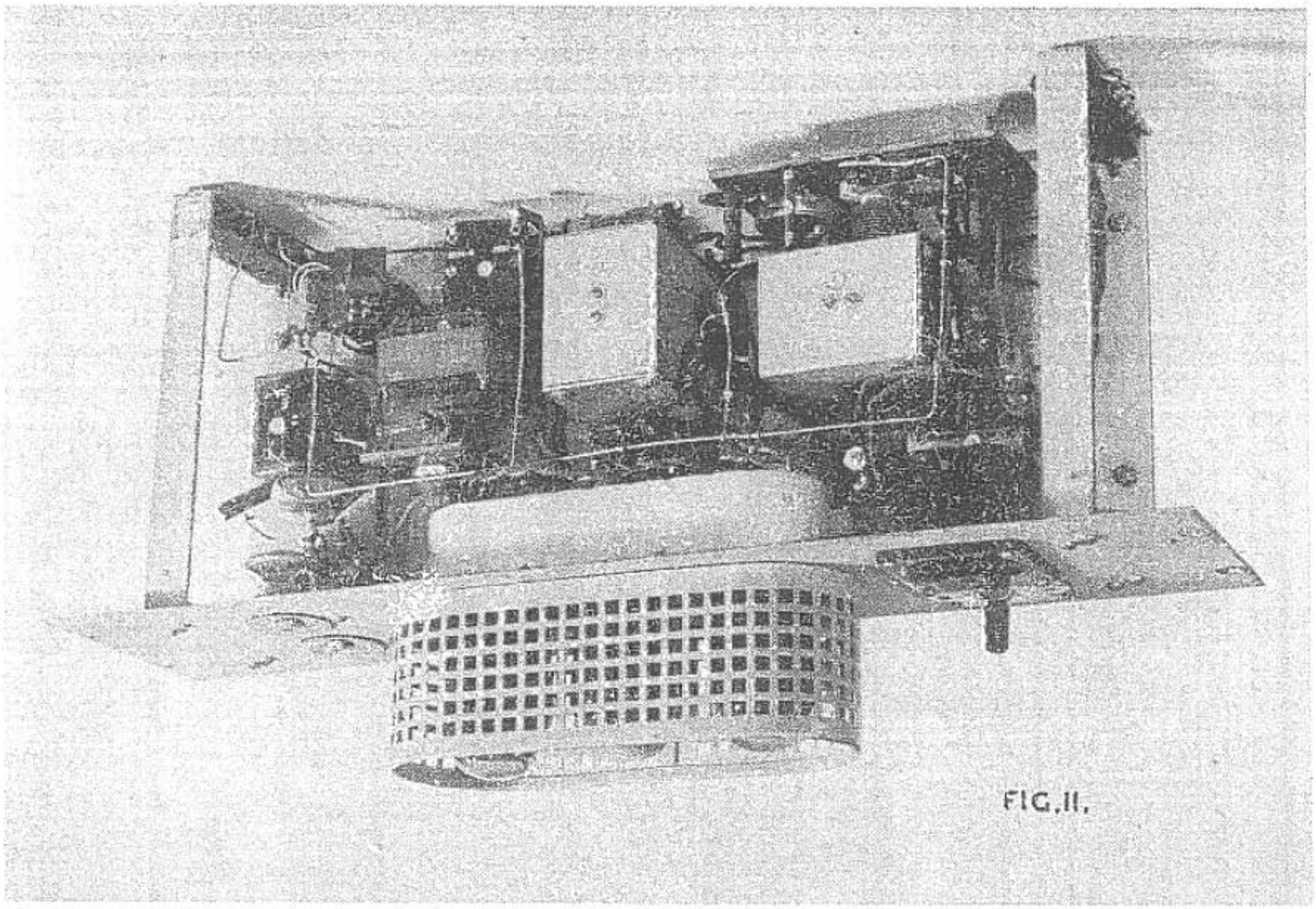


FIG.11.

FIGURE 11

Magnetophon Sound Recorder and Reproducer, Type HTS

Recording amplifier, type V7b. This uses 3 valves type EL11. In addition to providing the necessary amplification and frequency response correction of the programmes to be recorded this unit generates alternating current at 35 to 40 kc/s for the wiping head and also current at 80 to 100 kc/s for the recording head. A 3-position key and a meter seen on the right enable wiping, biassing or programme current to be read. On the left of the valves are controls adapted for screwdriver adjustment, for frequency response (above) and gain (below).

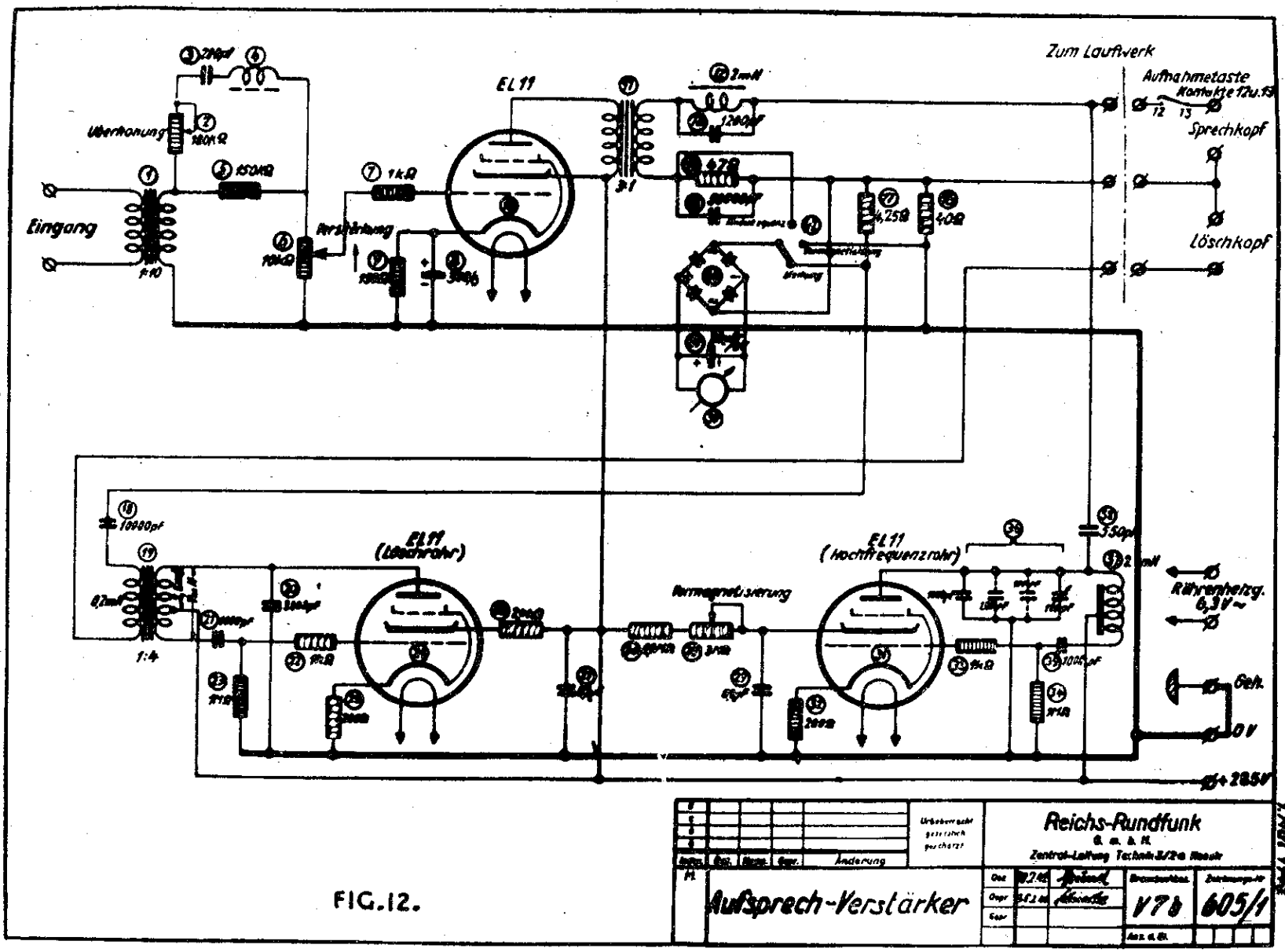


FIG.12.

Urheberrecht gerichtlich geschützt						Reichs-Rundfunk G.m.b.H. Zentral-Leitung Technik 3/2a Masik			
Index	Tag	Name	Gepr.	Änderung					
A					Aufsprech-Verstärker	Gez.	27.10.	Schmidt	V 76	605/1
						Gepr.	3.11.38	Schmidt		
						Satz			Ausg. d. BI.	

A I V 76/2
1. Mai 1940

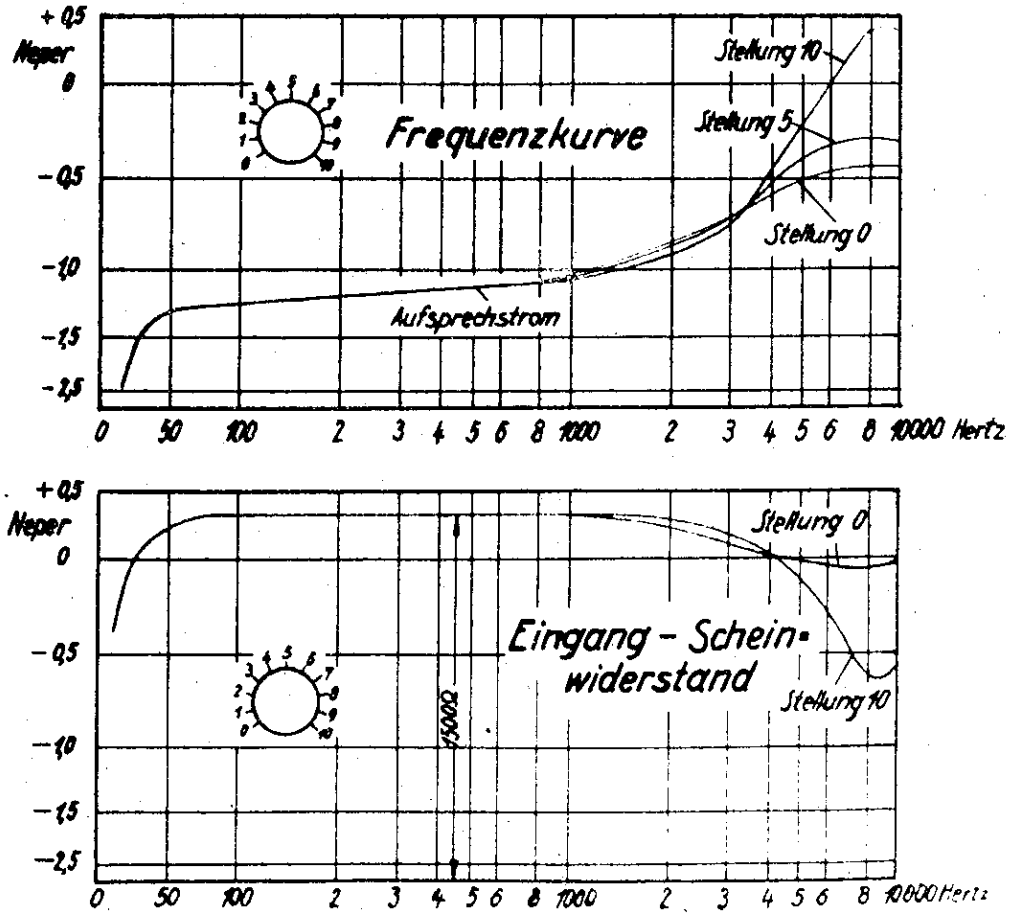

+0,5
Neper
0
-0,5
-1,0
-1,5
-2,5
Frequenzkurve
Stellung 10
Stellung 5
Stellung 0
Aufsprechstrom
0 50 100 2 3 4 5 6 8 1000 2 3 4 5 6 8 10000 Hertz
+0,5
Neper
0
-0,5
-1,0
-1,5
-2,5
Eingang - Schein- widerstand
Stellung 0
Stellung 10
15000
0 50 100 2 3 4 5 6 8 1000 2 3 4 5 6 8 10000 Hertz

FIG. 13.

casting to which high permeability covering plates are fitted to provide electro-magnetic screening. The whole head assembly is easily interchangeable, being withdrawn from the machine plate by removing the slotted screws at either end (see also fig.6)

The heads, which are annular in shape, are made of laminated permeable metal. Each ring comprises two symmetrical parts, each part carrying half the turns. The wiping head has a gap of about 0.5 mm with a copper spacer. The recording head gap is 0.045 mm. ± 10% and the reproducing head gap 0.02 mm. ± 10%. The recording head is fitted with an additional gap of 0.3 mm at the rear to reduce residual magnetism caused by strong surges.

The current in the wiping head is about 150 mA at 35 - 40 kc/s; it should not fall below 120 mA. The recording head carries a biassing current of 10 mA peak at 80 - 100 kc/s: peak audio frequency current at 1 kc/s is 5 mA.

Electrical data:-

(i) Wiping Head

2 x 75 turns
Inductance: 2.0 ± 0.2 mH. when new
1.5 mH approx. " worn

(ii) Recording Head

2 x 150 turns
Inductance: 7.0 ± 1.0 mH. when new
5.0 mH approx. " worn

(iii) Reproducing Head

2 x 250 turns
Inductance: 80 ± 5 mH. when new
55 mH approx. " worn

Weight: 2.2 lbs.

(c) Recording Amplifier V7b: A general view of this is shown in fig.11 and the circuit diagram in fig.12. It contains also a frequency correction network and oscillator valves for producing the wiping and biassing currents.

The amplifier and correction network are shown in the upper part of circuit diagram. The audio-frequency input having a peak value of 1.5 v. is applied to the terminals of the input transformer from a low impedance source. After being stepped up by the 1:10 transformer, the voltage is applied to the grid of an EL11 valve via a voltage divider. The fixed portion of this (5) is by-passed by a corrector circuit designed to give a variable tip-up to the higher audio-frequencies, depending on the adjustment of the variable resistor (2). The potentiometer(6) is used as a gain control. The EL11 is pentode-connected, using its comparatively high internal resistance to produce a constant current independent of frequency (neglecting the correction circuit) in the recording head, which is effectively inductive. On the output side is a rejector circuit (12,13) to keep out H.F. The peak audio-frequency current at 1,000 c/s is about 8 mA.

The input impedance of the amplifier is 1,500 ohms at low and middle audio-frequencies, falling at high frequencies to 360 ohms with the corrector at its maximum, or to 650 ohms with the corrector at its minimum. Variation of input impedance with frequency under both these conditions is shown in the lower diagram of fig.13.

The lowest input voltage which will produce a current of 8 mA in the recording head is 0.5 v: for higher values of input voltage the correct output current is obtained by adjusting the potentiometer (6). At the higher audio-frequencies the output current can be varied by adjustment of the corrector. The frequency response curves for the extreme settings of the corrector control are shown in the upper diagram of fig.13.

When the "RECORD" button is pressed, contacts 12 and 13 close and connect the recording head to the amplifier. These contacts must close after H.T. has been switched on via contacts 23 and 24: this is achieved by suitable adjustment of the contacts, and prevents the recording head being magnetised by surges following the switching on of the H.T.

Wiping current is generated by an EL11 valve with regenerative feedback. The frequency of this current, which should be at least 120 mA, is between 35 and 40 kc/s. Coupling to the wiping head is effected by a 4:1 step-down transformer. The coupling condenser (18) is tuned with the inductance of the wiping head to the frequency of the wiping current. The wiping head is permanently connected.

Biassing current is generated by a third El11 valve. The arrangement is shown in the bottom right-hand corner of the circuit diagram. The frequency of this current is between 80 and 100 kc/s and can be varied by means of the condenser, (36): the current can be varied between 5 and 15 mA by adjusting the screen volts. The biassing current is superimposed on the audio-frequency current via the coupling condenser (38).

The values of audio-frequency, wiping and biassing currents can be read on the meter (39) by setting the selector switch (42) to the appropriate positions.

Power is derived from the mains unit N7b. The heaters are permanently connected under standby conditions but, as already explained, H.T. is only applied to the valves when the "RECORD" button is pressed. To avoid voltage fluctuation of the mains unit under no-load conditions, a dummy resistive load is connected across contacts 23 and 22. H.T. consumption is 100 mA at 285 v: heater consumption is approximately 2.7 amps. at 6.3 v.

Ripple voltage is approximately 10 mV measured across resistor 14.

Dimensions:
$19\frac{1}{2}$" x $4\frac{3}{4}$" x $6\frac{3}{4}$"

Weight:
11 lbs.

(d) Reproducing Amplifier V5: A general view of this is shown in fig.14 and a circuit diagram in fig.15. Its function is to amplify the output from the reproducing head and also to introduce frequency correction.

The voltage from the reproducing head is stepped up in the ratio of 62.5:1 and applied to the grid of the first valve, type EF12. The secondary of the transformer is loaded with a .5 megohm resistor, this tending to level out the frequency characteristic which would otherwise rise with frequency. Further correction is provided between the first and second stages by a voltage divider comprising resistor (20) and condenser (21) in series with the resistor (22). To boost the highest and lowest frequencies, there are two resonant circuits in series with one another, shunting the anode circuit of the first valve. The high frequency boost can be controlled by the .5 megohm resistor (10). This adjustment appears as the left-hand control on the front panel (fig.14).

The second stage consists of an EF12, triode connected. In the anode circuit of this valve is a filter with a cut-off frequency of approximately 15,000 c/s., whose function is to suppress any stray beat frequencies which may be produced by the H.F. oscillators in the recording amplifier.

The output is matched into 200 ohms. Gain is controllable over a range of 7 db by means of the resistor (32): this appears as the right-hand control on the front panel (fig 14).

Power is derived from the mains unit N7b. The valves are heated with D.C. and as the D.C. source has a high internal resistance, removal of one valve will increase the heater voltage on the other to 10 v., thereby endangering it.

The input impedance of the amplifier is approximately 10 ohms independent of frequency. The output impedance however depends on setting of the gain control (32) and varies between 200 and 700 ohms.

As has already been pointed out, gain is dependent on frequency. When making a measurement of the overall gain of the amplifier, a special input circuit must be used as shown in fig.16. This consists of a 0.1 mfd. condenser in series with a resistor of 2 ohms.

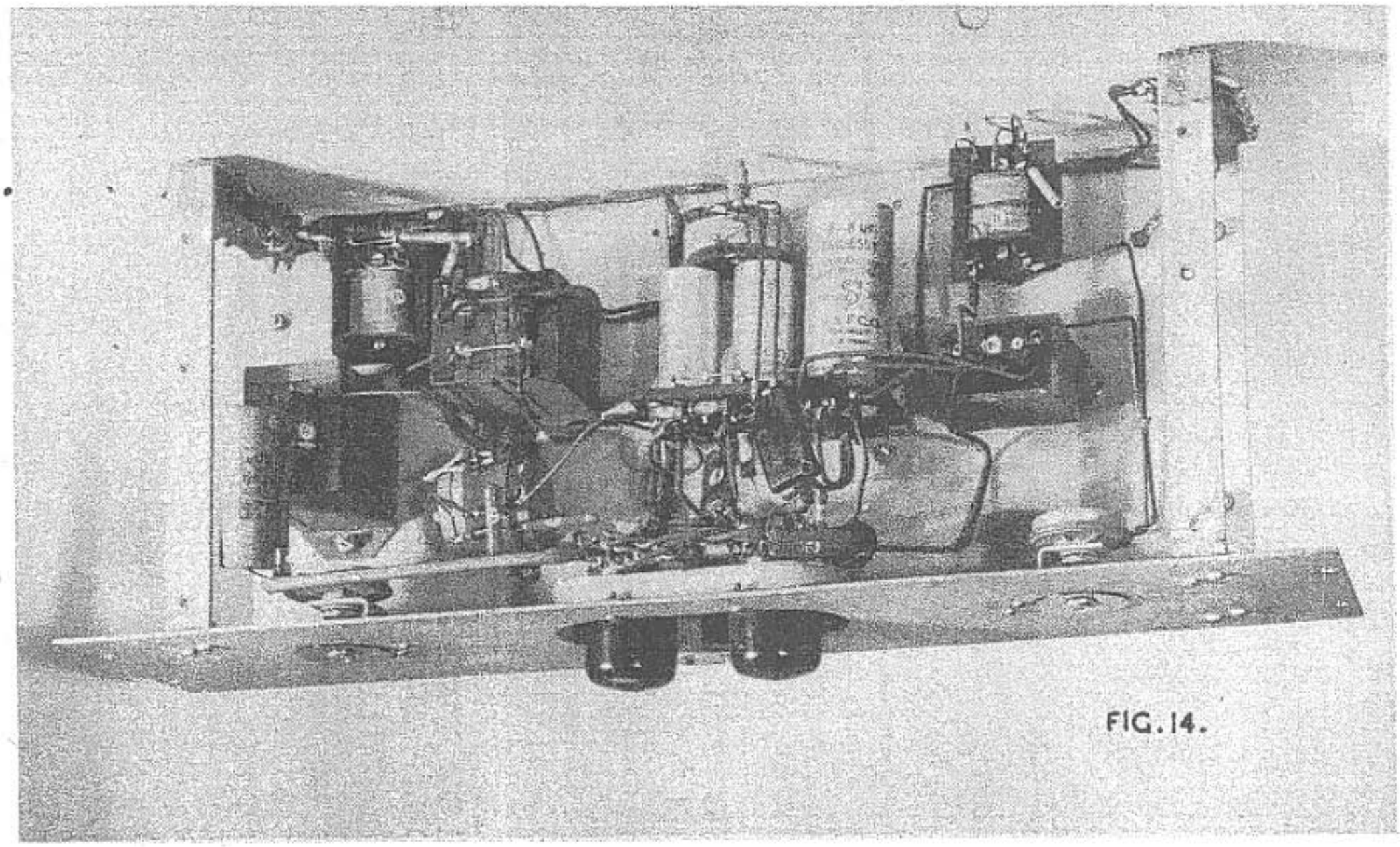


FIG. 14.

FIGURE 14

Magnetophon Sound Recorder and Reproducer, Type HTS

Reproducing amplifier, type V5. This uses two valves type EF12. It amplifies the programme picked up by the reproducing head and applies the requisite frequency response correction. On the left and right of the panel respectively can be seen the screwdriver-adjustment controls for frequency response and gain.

A/V5/2
1. Mai 1942

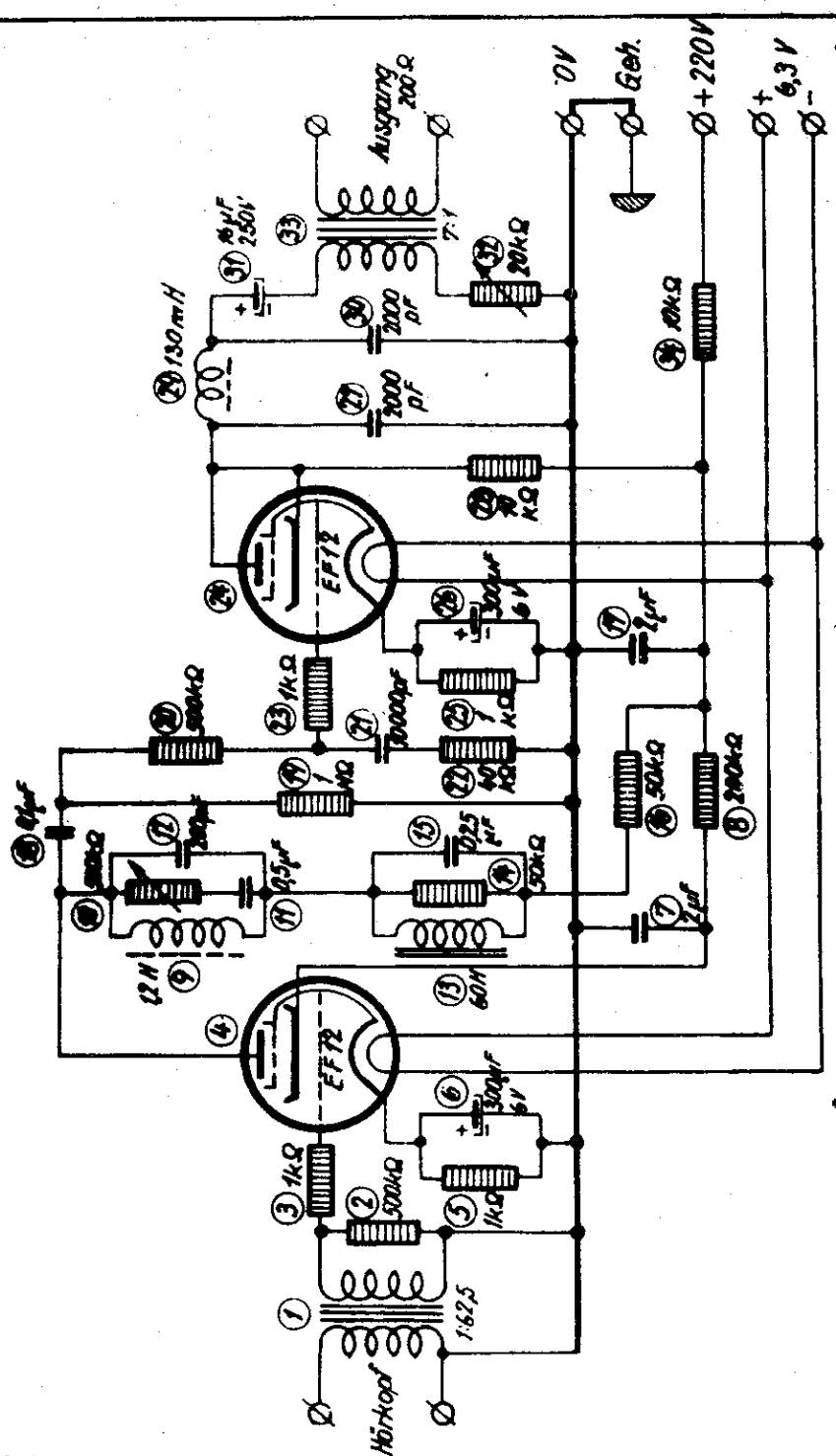


FIG. 15.

Index	Dat	Name	Copr	Änderung
d				
c				
b				
a				

Urheberrecht gesetzlich geschützt

Reichs Rundfunk
G. m. b. H
Zentral-Leitung Technik 3/2 a Konstr

M.

Wiedergabeverstärker

Gez	21.2.42	Krüsel	
Gez	25.2.42	Steinke	
Gez			
Genehm			

Braunbuchblatt-Nr: V5

Zeichnungs-Nr: 606/1

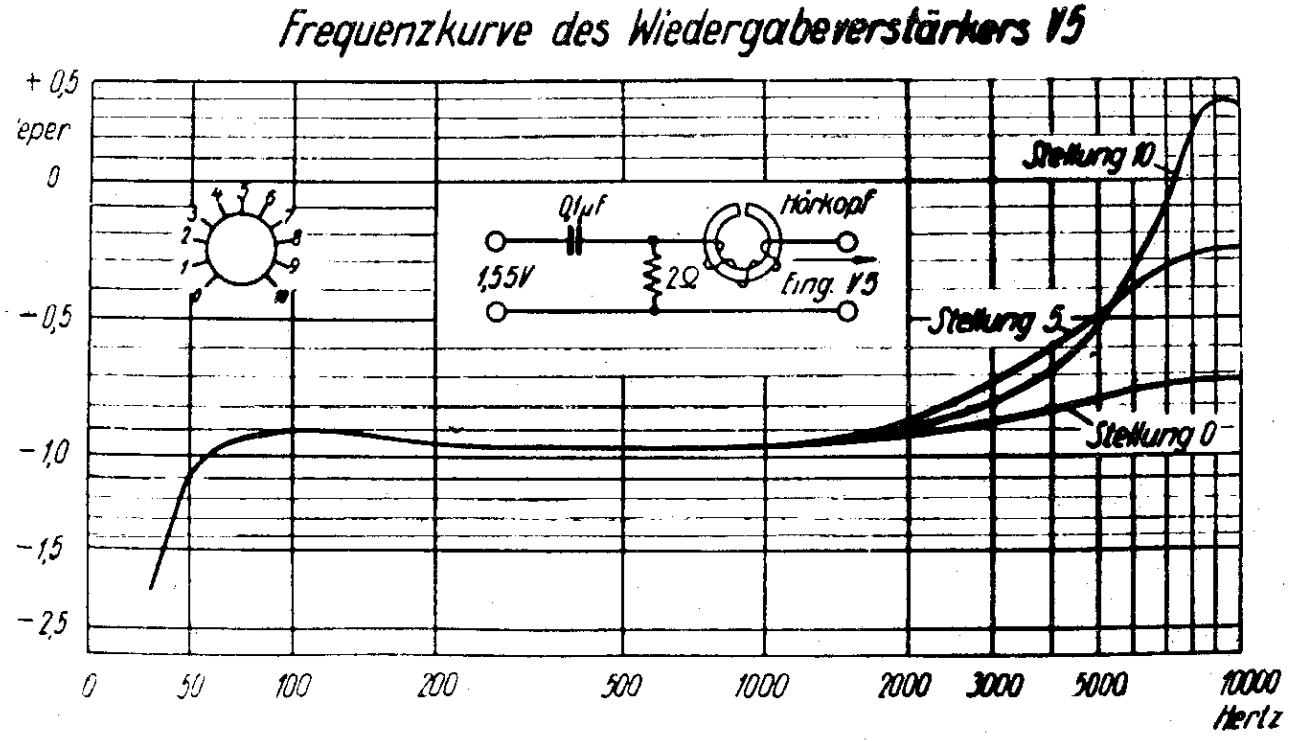

Frequenzkurve des Wiedergabeverstärkers V5
+ 0,5
eper
0
− 0,5
− 1,0
− 1,5
− 2,5
0
50
100
200
500
1000
2000
3000
5000
10000
Hertz
Stellung 10
Stellung 5
Stellung 0
0,1µF
Hörkopf
1,55V
2Ω
Eing. V5

FIG. 16.

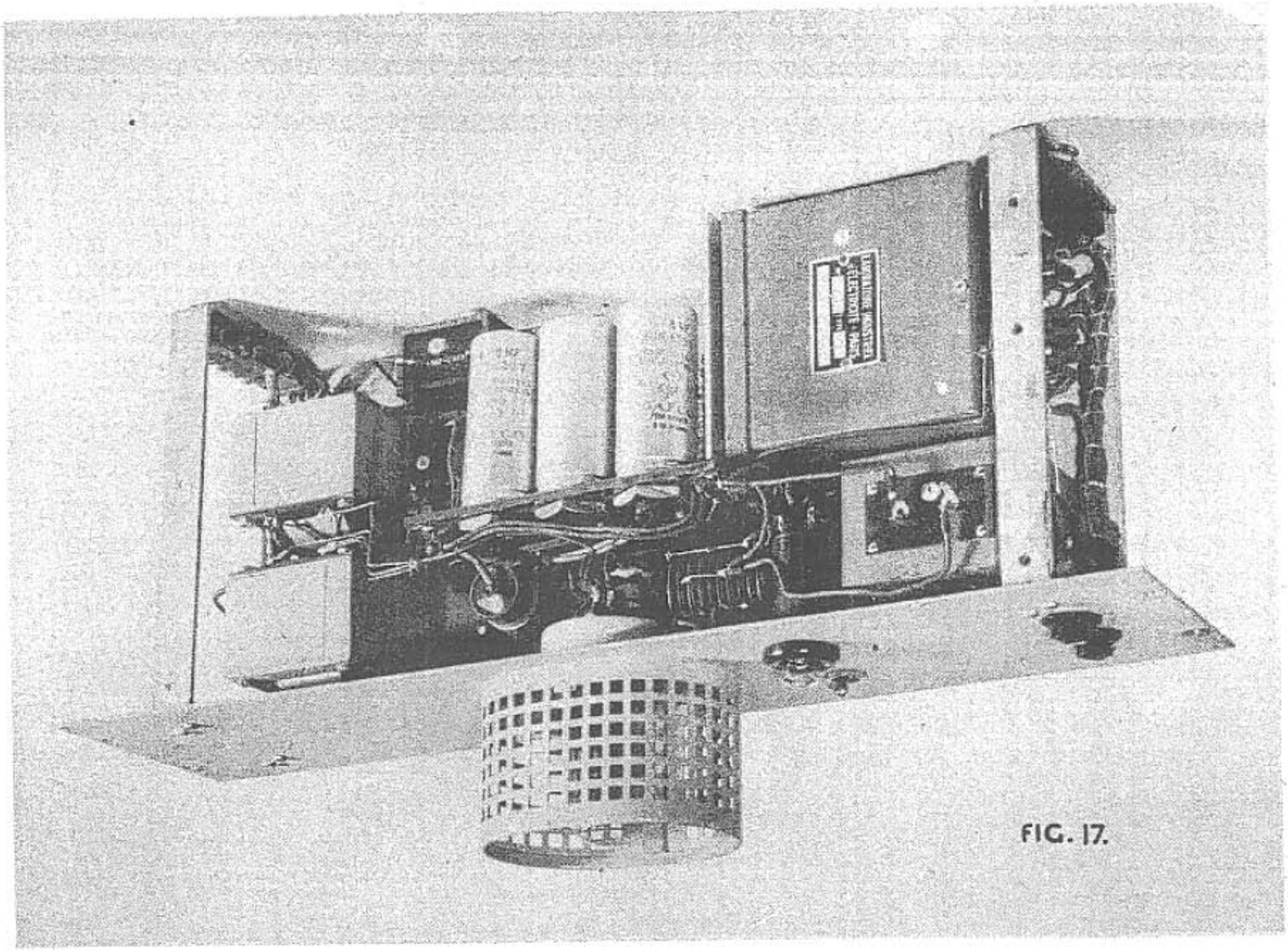


FIG. 17.

FIGURE 17

Magnetophon Sound Recorder and Reproducer, Type HTS

Mains unit, type N7b. This uses a single rectifying valve type EZ12. The unit supplies H.T. and L.T. current for both recording and reproducing amplifiers. On the panel can be seen the two mains fuses, mains switch and neon indicator lamp.

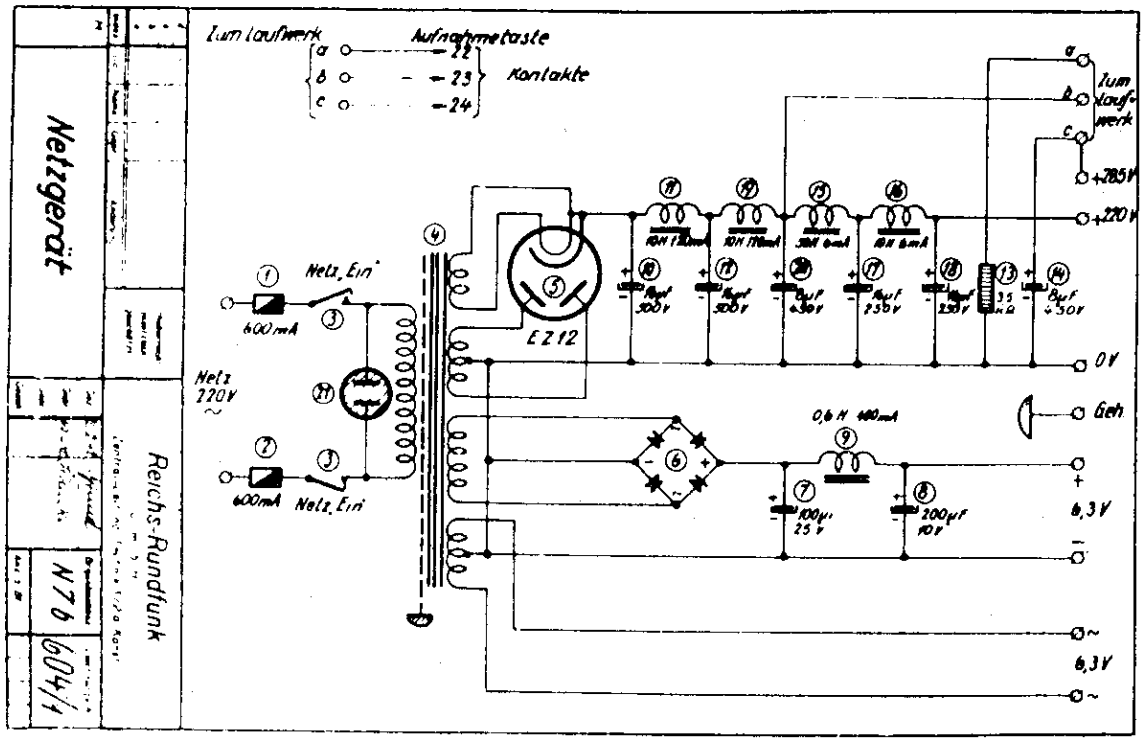

Netzgerät
Reichs-Rundfunk
N 76
604/1
Zum Laufwerk
Aufnahmetaste
a
b
c
22
23
24
Kontakte
Netz, Ein
600mA
Netz 220V
EZ12
0,6 H 60mA
Geh
0 V
6,3 V
6,3 V
Zum Laufwerk
+285 V
+220 V

FIG. 18.

The voltage developed across this resistor is applied in series with a reproducing head to the input of the amplifier. The output should be loaded with a 200 ohms resistive load and the gain control set at maximum. Under these conditions the overall gain at 1,000 c/s should lie between 15.5 and 21 db.

The frequency response is measured in a similar way, by applying to the input terminals of the auxiliary circuit a sinusoidal voltage of constant e.m.f. at all frequencies. Fig.16 shows the frequency response which should be obtained at each of three settings of the frequency correction control.

Ripple voltage should not exceed 0.35 mV and noise voltage should not exceed 0.15 mV measured across the output.

Dimensions:
$19\frac{1}{2}$" x $4\frac{3}{4}$" x $6\frac{3}{4}$"

Weight:
$7\frac{1}{2}$ lbs.

(e) Mains Unit N7b: A general view is shown in fig.17 and circuit diagram in fig.18.

The mains unit operates from A.C. 220 v. 50 c/s and supplies power to both recording amplifier V7b and reproducing amplifier V5.

A rectifier valve type EZ12 is used and there are three circuits, one for H.T., one for the heaters of the recording amplifier valves and a third for the heaters of the reproducing amplifier valves.

H.T. for the recording amplifier is taken off at the point b, the maximum drain being 120 mA at 285 v. Under recording conditions points b and c are connected via contacts 23 and 24: under all other conditions b is connected to a, thus by-passing the H.T. through the dummy load (13.) This connection is made via contacts 22 and 23 when the "RECORD" button is released. Part of the H.T. is passed through further

filters to the reproducing amplifier, the drain in this case being 6 mA at 220 v. A D.C. supply of 0.4 amps at 6.3 v. for the heaters of the EF12's is produced by a selenium bridge rectifier. An A.C. supply of 2.7 amps. at 6.3 v. for the heaters of the valves of amplifier V7b is provided direct from a secondary winding of the mains transformer.

The input to the transformer primary is 75 VA at 220 v.

Dimensions:
19½" x 4¾" x 11"

Weight:
28½ lbs.

Performance: Frequency response is level within ± 3 db from 50 to 9,000 c/s. When the level of a sinusoidal input at 1,000 c/s is adjusted so that the total harmonic content is not greater than 4%, the ratio of peak signal/background noise, measured via an aural sensitivity network, should be at least 55 db.

(10) KZ

Purpose: High quality recording and reproduction of speech and music for broadcasting: for use under conditions in which the equipment is to be permanently installed: for use in conjunction with another similar machine for the recording and reproduction of continuous programmes of long duration.

NB: THIS TYPE IS A DEVELOPMENT OF THE HTS AND NO MODEL HAS SO FAR BEEN INSPECTED. THE FOLLOWING DETAILS ARE DERIVED FROM INFORMATION SUPPLIED BY AEG:-

Description: The equipment is in the main similar to type HTS though a number of detail changes and improvements have been made. The principal of these are as follows:-

(a) Eddy-current motors are used instead of series commutator motors, for driving the two turntables.

(b) A control is provided on the motor-board which enables the speed of the tape to be continuously varied from full-speed forward to full-speed reverse. This enables a particular spot in

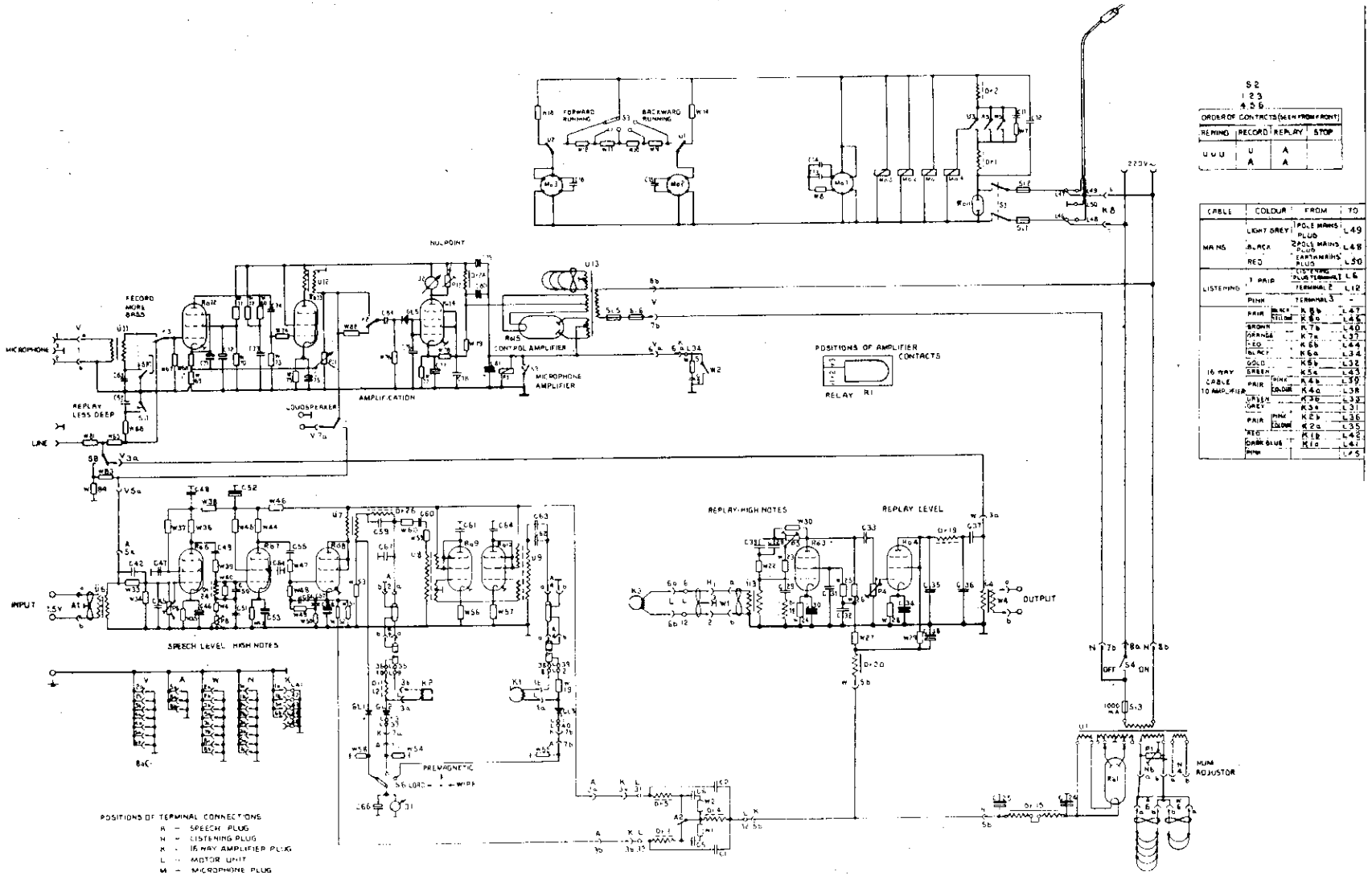


FIG. 19.

CIRCUIT DIAGRAM FOR MODEL K7 MAGNETOPHON AEG/AT/MGT
403178 N

the modulation to be located quickly and should thus facilitate editing.

(c) A tape indicator is provided in the form of a clock and is driven from the right-hand guide roller. The scale indicates elapsed minutes and seconds.

(d) There is a proposal to provide a fully automatic method of synchronous changeover between successive reels on reproduction. It is not known whether this has yet been developed to a satisfactory state.

(e) Screening of the heads has been improved.

(f) A means is provided for disengaging the tape from the head assembly during rewinding, thereby reducing wear on the heads.

(g) The biassing frequency is approximately 200 kc/s as compared with 80 - 100 kc/s on the HTS.

The circuit diagram is shown in fig.19. A larger scale version of this together with a list of component values is available in B.I.O.S.Library.

Performance: The frequency response is said to be level ± 2 db between 50 and 10,000 c/s. At the same time it is stated that when a sinusoidal input at 1,000 c/s is adjusted in level to give a total harmonic content of not more than 3%, the ratio of peak signal/background noise, measured via an aural sensitivity network, is at least 60 db.

(11) Kassettengerat:

Purpose: For reproduction only, not recording: for domestic use employing a continuous loop of tape enclosed in a cassette.

Description: A model was demonstrated at the Kiel factory of AEG. This was in an early experimental form and design work was being continued.

The overall size was approximately 9" x 9" x 7". The tape was contained in a flat metal cassette 9" x 5" x ¼" thick with a rectangular window of about 2" x 1" in the centre. This contained a spool of

some 300 metres of tape in an endless band, a free loop of the tape being brought out from the centre of the spool, carried across the window and around pulleys to the outside of the spool. The turns of tape were freely wound so that they would slide easily over each other. A light driving force applied to the tape exposed in the window drew the whole length of tape around at a fairly steady speed. The loop of tape was driven by a rotating metal cylinder 3.6 mm. in diameter, on the spindle of a small 1,500 r.p.m. synchronous motor pressing the tape against a hard rubber roller, the tape running at 28 cm/sec.

The body of the apparatus housed an amplifier, mains unit and small loudspeaker. From the centre of the top panel there stood up by a fraction of an inch a Magnetophon annular reproducing head. The cassette was located on pegs on this top panel so that the user could easily slip the tape loop into its correct place over the reproducing head. Cassettes could be readily interchanged. The tape speed of 28 cm/sec. involved considerable attenuation of the upper frequencies and it is probable that there was a cut-off at about 4,000 c/s. There appeared to be mechanical difficulties caused by friction of the turns of tape sliding over each other. This produced variations of tape speed with consequent variations in the pitch of the reproduced sounds.

(12) Machine for Recording on a Quarto Sheet:

Purpose: To enable recordings to be made in a form in which they can be sent by letter-post and conveniently filed.

Description: No model of this instrument was seen and it appears doubtful whether it has even got beyond the drawing-board stage. The idea, apparently, is to use as recording medium a sheet of the material from which the Magnetophon tapes are cut. The method of recording is to move the recording head to and fro across the sheet whilst the latter is drawn slowly past the head in a direction at right-angles to the direction of motion of the head itself. For reproduction the sheet would be "scanned" by a reproducing head moving in an exactly similar manner to the recording head.

6 THE TAPE

Appendix I gives details of the composition of the three types of tape C, L and LG. This is derived from a paper written in German by Dr.Pflaumer (or Pfleumer) of IG Farben and translated into English by Dr.von Braunmühl. No attempt has been made to edit this translation.

So far as could be ascertained, the only type of tape now being manufactured in Germany is the latest type, LG. A brief description of the method of manufacture is as follows:-

At the factory of IG Farben at Ludwigshafen, polyvinyl chloride, whitened with Titanium White, is rolled into sheets 60 cm. wide, 400 metres long and about .05 mm. thick. The sheets are drawn under tension over a series of four electrically heated rollers in order to stretch the sheet longitudinally, its width being reduced to 32.5 cm. and its length increased to 1 km., the thickness being reduced slightly to approximately .04 mm. There are four heated rollers, the first one being at 180° C. and the others revolving a little faster and being heated to a slightly greater temperature, increasing progressively, the final speed of sheet being 1 km. per hour. This operation, known in Germany as "luvitherming", appreciably increases the tensile strength of the tape in a longitudinal direction.

The stretched sheet is delivered in rolls 1 km. long and 32.5 cm. wide to a garage in the village of Aschbach near Wald Michelbach, where themagnetisable layer is applied. This red-brown layer consists of ferric oxide rolled on to one side of the tape only. The oxide mixture is also obtained from IG Farben, Ludwigshafen, made from ferrous sulphate $FeSO_4$ treated with ammoniac Na_4OH, producing a black oxide Fe_3O_4 which is heated to 280° C. or 300° C., becoming red-brown.

This material is milled to a fine powder and air-blown through a fine mesh sieve into containers, the particle size being 0.2 to 1 micron. The resultant fine powder is mixed with an equal quantity of p.v.c. powder and a small proportion of solvent and plastifier at Ludwigshafen, being despatched in the form of small lumps ($\frac{1}{8}$" - $\frac{1}{4}$").

At Aschbach the lumps are finely milled in a ball mill and made up into a fluid paste as follows:-

Iron oxide mixture	40 parts
Benzol	10 "
Tetrahydrofuran	15 "

The sheet coating plant is about 10 metres long and 1 metre wide, consisting of a series of rollers for handling long lengths of sheet. At the input end there is a spreading device with a bridge piece for levelling off the coating of oxide mixture to a constant thickness. The mixture is held in a hopper and is kept constantly mixed by means of a small motor-driven paddle right up to the moment of trickling into a trough located immediately above the sheet. The thickness of deposit is .015 mm. A thick deposit gives a shorter magnetic working range, whilst a thinner deposit results in inadequate magnetisation. The coated sheet is drawn through a 5-metre long tunnel, through which a current of hot air (about 25° C) is constantly drawn, at a velocity of 5 cm/sec. (taking five hours to run through 1 kilometre length).

The tunnel opens out into a large chamber about 2 metres square to form the final drying stage. About 16 metres of sheet are spirally wound round little rollers in about four turns, starting from the outside and working inwards, the sheet debouching from the centre of the chamber at right-angles to the main tunnel through a narrow slit, after which it is wound up on a bobbin driven by a slipping clutch.

There are thus about 20 metres of sheet in the drying tunnel and chamber at any time, each portion of the sheet taking about 6 minutes to pass through completely.

There was no evidence of the use of a travelling band carrier to assist the sheet through the drying tunnel.

The coated sheet is then taken to the village of Wald Michelbach to another shed where it is slit into strips 6.5 mm. wide, some 40 strips being cut from the sheet at a time by circular rotating knives on paper slitting machine. Each strip is wound up

on one of a set of special cores clamped axially on a mandrel.

Each spool of tape is then inspected visually for flaws, such as intermittent spreading of the oxide, and wound on to the commercial core for shipment. Faulty patches of tape are cut out and the ends joined together in a few seconds by scraping away the oxide with a razor blade and sticking with cyclohexanone.

Electrical tests are made on each tape by running the tape through a machine similar to a Magnetophon recorder and reproducer, the tape being magnetised with a known voltage in the recording head and a trace of the reproduced voltage from the reproducing head being made visually. This test is carried out at 1,000, 5,000 and 8,000 c/s.

Spools of tape are finally boxed in stout cardboard for shipment.

7 PATENTS

Information about patents is incomplete. Appendix V gives a list of Patents issued up to and including June 3rd, 1944, which is believed to be complete (List A). Photostat copies of all of these will be made available at Board of Trade, German Division(Documents Unit),Lansdowne House,Berkeley Sq.,W.1.

A number of additional patent applications have been filed, mostly in the name of Braunmühl and Weber, and it is possible that patents have been granted in respect of some of these. List B of Appendix V gives as much information as is at present available on these. Photostat copies of a few of the applications referred to in this list will be made available at the Board of Trade, German Division (Documents Unit), Lansdowne House, Berkeley Sq.,W.1.

8 REFERENCES

(1) "Magnetische Schallaufzeichnung mit Filmen und Ringköpfen" (Magnetic Recording using Tape and Ring-shaped Heads) by H.Lübeck. Akustische Zeitschrift, 1937, Heft 6.

(2) "Some Aspects of Magnetic Recording and its Application to Broadcasting" by A.E.Barrett & C.J.F.Tweed. Journal of the I.E.E., Vol.82, No.495, March 1938.

(3) "Der Heutige Stand der Schallaufnahmtechnik und ihre Anwendung beim Deutschen Rundfunk". (The present state of the Technique of Sound Recording and its Applications to Broadcasting in Germany) by H.J. von Braunmühl. Akustische Zeitshrift, 1938, Heft 5.

(4) "The Mechanism of Supersonic Frequencies as Applied to Magnetic Recording" by H.Toomin and D.Wildfeuer. Proceedings of the I.R.E. Vol.32, No.11, November 1944.

(5) "Use of A.C. Biassing in Magnetic Recording" by W.Makinson and B.G.Gill. Technical Note No.RAD.305, Royal Aircraft Establishment, Farnborough, June 1945.

(6) "Investigations on New Magnetic Recording Media (final)". C.R.B. Report No.45/5887, June 1945.

(7) "Supersonic Bias for Magnetic Recording" by L.C.Holmes and D.L.Clark. Electronics, July 1945.

(8) "The AEG Magnetophon, Model K7". RAT.43 Document G, January 1946, will be lodged with Documents Unit.

FD69/47 (9) "Description of the Magnetophon, Types K4, HFS and K7" RAT.43 Document L, January 1946, will be lodged with Documents Unit.

(10) "The Magnetophon, its Properties and Fields of Use" by H.J.von Braunmühl. RAT.43, Document P, January 1946, will be lodged with Documents Unit.

(11) "High Frequency Magnetic Sound Recorders" F.I.A.T. Final Report No.705.

(12) "The Magnetophon of AEG." B.I.O.S. Final Report No.207.

(13) B.I.O.S. Group 1, Interrogation Report F.159.A. March 1946.

(14) "AGFA Colour" B.I.O.S. Final Report No.397 Item 9. Brief reference to Magnetophon Tape.

(15) B.I.O.S. Evaluation Report 371.

(16) "S.I.G.E.S.O. 56" Sheet of Section 1. Short Report on Magnetophon, A.1000 L40.

(17) "I.G. Farben Industrie". C.I.O.S. Report XXVII - 84 Brief Report on Magnetophon Tape.

Note.

Documents referred to as being lodged with Documents Unit, will be made available for inspection at:-

Board of Trade,
German Division (Documents Unit),
Lansdowne House,
Berkeley Square,
London, W.1.

Tel: Grosvenor 4060, Ext: 2923.

A P P E N D I X I

Notes on the manufacture of Magnetophon tape, by Dr.Pflaumer of I.G.Farben, translated by Dr.H.J.von Braunmühl.

Report on fabrication of Magnetophon Tapes

The development of sound recording with the Magnetophon process represents a common work of the AEG/Berlin and the IG/Ludwigsnafen. The AEG specially dealt with the problem of the recording apparatus and the different types developed whereas the IG made the investigations concerning the recording tape and introduced its fabrication on a large scale.

The electromagnetic method for sound recording is very old. At first a steel wire or steel tape was used for recording. This method was sufficient for pure dictating purposes, but not for the requirements for the reproduction of sound involved by the development of broadcasting. Utmost absence of background noise and greatest sensitivity from 1000+) to 10,000 c/s should be reached. The first experiments to replace the steel tape by a film of artificial resin were undertaken as early as in 1932, but not before 1939 a tape was available, the properties of which corresponded to a higher degree of quality as to the pureness of tone and the dynamic range (proportion of noise to sensitivity)++). The main development and the general introduction of the Magnetophon process in German Broadcasting took place during the war.

For different military purposes special apparatus had to be developed e.g. the types b, c, d, RE3 and the HF-type K7. There were built: knapsack apparatus, suitcase recorders for the reporters of the "Propaganda Companies", listening devices, etc. Exact indications, which type of recorders were used for different purposes cannot be given by us, because these orders went to a great part under "secret" to the AEG without informing us. Informations thereabout can be given by Dr.Schepelmann of the Magnetophon-GmbH, at this time in Hamburg (could be reached via "Verkaufskontos der IG-Farbenindustrie"). The type for German Broadcasting was - as far as we know - the recorder RE3. The latest development is represented

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+) 10,000 c/s must be an error (The translator)
++) Not quite correct; seems to be an abbreviation taken from checking prescriptions elaborated by the former RRG (The translator).

by the HF-recorder K7. This recorder corresponds practically to all wishes as to a natural reproduction, and that also by the fact that the quality of tapes was more and more improved during continuous and difficult developing efforts.

Selling of the apparatus fabricated by the AEG and the tapes manufactured by IG was effected by the Magnetophon GmbH, Berlin. This organisation was a pure selling company with a funds of RM 400 000.- at which the AEG and the IG participated 50% each. In the same manner, the profit of this company, which had also to effect the whole advertising work, was subdivided with 50% between the mother-houses, non regarding the values of materials furnished by each of them.

The 3 steps of development of the tape were:

I+) Older step: Tape type C, two layer tape on the Cellite-basis (Acetyle-cellulose) coating process.

II step: Tape type L, single layer tape in the Luvitherme basis. (Polyvinyle-chloride) Rolling process.

III Latest step: Tape type LG, double layer type. Rolling and coating process.

This development was completed not before the last days. Before giving details, the different types may be characterised as follows:

I - Type C

Acetylecellulose is dissolved in Acetone. The viscous solution is filtered and then coated upon the infinitive copper tape of a coating machine, 20 m. long, the coated tape being about 55 cm. broad. The basic film layer dryes on the copper tape and after having passed the machine at a length of about 4 meters, the Magnetite, dispersed in acetone-acetylcellulose is coated upon it. The whole tape is rolled up after complete drying.

+) The complicated chemical expressions are taken more or less as they are in the original report.

II - Type L (single layer tape)

For type L, Igelite PCU is utmost finely ground together with Magnetite in the proportion 50 : 50 and sifted by an air stream. Upon a heated rolling device the mixed powder is rolled 4 - 5 times, then brought on a heated calander to the form of a film and finally stretched with a special machine in the proportion of 1 : 2½ (Luvithermed).

III - Type LG

Igelite PCU is rolled like normal insulating films as indicated in II. only with addition of 1% dioxide of titane. Upon this raw film a dispersion of magnetite in two parts of tetrahydrofurane and one part benzole with MP-400 material (mixed polymerisate of vinyl-chlorid and vinylisobutylether) is coated by means of a special coating machine developed by ourselves.

I - Magnetophon Tape Type C

a) the basic layer

Required basic materials:
- Cellite
- Acetone pure
- Phenylphosphate
- Palatinol C

Cellite:

Chemical character:	About 2½ times acetylized cellulose. Used marke: L 1000.
Preparation:	Cellulose is treated with anhydrid of acetic acide and "Eisessig".
Properties:	Dry, granulated material, dissolvable in acetone.
Application:	Groundmaterial for the basic layer.
Furnisher:	Dormagen.

Acetone Pure:

Furnisher:	Höchst.

Phenylphosphate:

Chemical character:	Triphenylphosphate
Properties:	Nearly white material
Application:	In an admixture of 14-15% to Cellite
Furnisher:	Bitterfeld.

Palatinol O

Chemical character:	Dimethylglykol-Phtalate.
Production:	"Veresterung" of phtale-acid with dimethylglykole.
Properties:	Thickly liquid material.
Application:	In an admixture of about 2½% to Cellite (referred to the dry material) as a smoother.
Furnisher:	Ludwigshafen.

b) The Magnetite Dispersion

Original materials:	Collodium wool, alcohole humid. Acetone Phenyl-phosphate Palatinol O Oil Rhizinus Magnetite.

Collodium wool:

Chemical character:	Nitro-cellulose with ca 11% nitrogen. Used are the types E 950 and E 1250.

Preparation: Slow nitration of cellulose

Properties: Humid flooked material; ca 65% dry substance.

Application: Imbedding material for Magnetite

Furnisher: Eilenburg.

Acetone
Phenyl-phosphate see a) basic layer
Palatinol O

Oil Rhizinus:

Chemical character: Oxy-oil-acid-glycerine-ester. Vegetable oil.

Application: In a 40 - 45% admixture to collodium wool (referred to the dry material) as a smoother.

Furnisher: Otto Aldag, Hamburg/ Braunlage.

Magnetite:

Chemical character: Magnetizable ferri-oxyde Fe_2O_3 = μ-iron-oxyde.

Preparation: From crystallic ferro sulfate ($FeSO_4$ $7H_2O$) (Furnishers: Oppau near Ludwigshafen resp. Bitterfeld/Saxonia)

25% ammoniac-water (Furnishers: Oppau) and ammonium nitrate (Furnishers Oppau)

From a solution of ferro-sulfate and ammonium nitrate in water, ferri-ferro-oxyde (black Magnetite!) is produced by 25% ammoniac. (Formerly, when manu-facturing tapes, the black

Magnetite ($=Fe_3O_4$) crystalling with crystal-water, was used. The recording on these tapes could not be wiped out later on; therefore now red Magnetite at 280 - 290° C in presence of air, it is transformed into red Magnetite (practical pure ferri-oxyde), the crystal water of the black Magnetite being eliminated.

Properties:

Micro-crystallic magnetizable powder of red brown colour. Diameter of the original particles less than 1/1000 mm. Specific weight about 4.5. The very fine grained powder has the tendency to agglomate during the different procedures of its production. Therefore it has to be finely ground and filtered in an airstream before use.

Applications:

a) For the production of Magnetophon tapes in Ludwigshafen and Wolfen/Saxonia

b) Under the name of "Polimag" for grinding and polishing optical glass

The material was furnished to: Carl Zeiss, Jena, Camera-plant, Munich. Optical Works, Nitsche and Günther, Rathenow. Emil Busch AG, Optical Industry, Rathenow. Optical Works G. Rodenstock, Munich. Voigtländer & Son AG, Brunswick. Ernst Leitz, GmbH, Optical Works, Wetzlar.

Furnishers:

Ludwigshafen.

Capacity: With the installations in Ludwigshafen and 5 work days a week there can be produced:

	10 mo	to+)
maximum	12 mo	to

If the double quantity is needed, additional apparatus have to be used.

Special attention has to be paid as to the best quality of the Magnetite. The diameter of the particles has to be smaller than 1/1000 mm. in any case, otherwise considerable complications would occur in the fabrication of the tapes. As a matter of fact, for the L type tapes, the film would become porous, and for the C type tapes, so called casting grooves would be seen. In both cases, the tape surface would not become smooth enough; in consequence of that the background noise will rise considerable and the dynamic range diminish in the same proportion. Therefore experimetal rollings and microscopic counting of the secundary particles is indispensable, before new production charges are used. The percentage of secundary particles should be less than 10%.

Production Method

The cast as well of the basic layer as of the magnetisable surface is effected in a continuous process with a special machine of the type likewise used for the production of photographic films. Upon an endless copper-tape the casting solution (a) is spread in a certain thickness. Then, the tape passes a drying channel (air stream and tape movement in opposite directions), where the acetone used for the solution of the Cellite evaporates; it is regained in a refrigerating system. At that spot of the drying channel, where drying of the basic layer is nearly perfect, a second coating system is installed, by means of which the Magnetite dispersion (b) is coated upon the basic layer. The film with its magnetisable surface continue to pass the drying channel.

+) The translator is not familiar with the expression "mo to"

At its end, the double-layer tape is taken off and rolled up. After having dryed completely, the tape is cut, re-rolled, checked and confectionned.

The casting of film is a nighest precision work, it requires the strictest observation of all necessary conditions and the most exact handling of coating machine. Special attention is to be paid to the properties of the Magnetite and the production of Magnetite dispersion.

Capacity

1 "charge" = 1000 m = 80 tapes type C requires a casting time of 6 hours.

When the machine will be used with maximum effect - whereby the casting time could be reduced eventually - a maximum production of 9000 tapes per month could be reached. These indications include the time necessary for cleansing and repairing etc. of the coating machine.

In July 1943 the tape manufacturing installation in Ludwigshafen was completely destroyed by an explosion. The production of the C type tapes was then transferred to the IG/Wolfen (Saxonia). Non regarding some "individual" changements, it is to be supposed that in Wolfen the principle of coating might have been the same as in Ludwigshafen. No details can be given concerning the capacity of the Wolfen installation in this moment. According to some uncontrolled informations it is said to be destroyed. The production of the C tapes is smaller compared with the former machine in Ludwigshafen, because the machine in Wolfen is shorter and narrower and its tape speed slower.

II - Magnetophon Tape Type L

Original materials: Igelite PCU type GH for L
Magnetite
IG-wax E
Stabilisator C

Igelite PCU type GH for L:

Chemical character: Polymere vinyle-chlorid

Preparation: From acetylene and "Salzsäure" (Vinyle-chlorid) and subsequent thermic. ploymerisation.

Properties: White, smooth powder. Can be formed into very rigid foils by rolling, melting and expanding (Luvithermisation).

Application in tape manufacturing: As baxic layer and imbedding material for the Magnetite.

Magnetite:

(see under I)

IG Wax E

Chemical character: Mentane acid, estered with aetnylene-glycole.

Properties: Medium solic, feebly yellow coloured artificial resin. Melting range 85 - 100° C. Soapable.

Application: In 3% admixture to Igelite as sliding material in the rolling and luvitherming process of the Igelite-Magnetite mixture.

Furnisher: Gersthofen.

ıbilisator C:

Chemical character. Diphenyle-tnio-"Harnstoff"

Properties: White, crystallinic powder

Applications: In a 0.3% admixture to Igelite for diminishing the "Salzsäure" production in the finished foil.

Furnisher: Höchst.

Scheme of Process

45% Igelite PCU, type GH for L
55% Magnetite, finely ground

mixed in mixdrum during 4 - 6 hours.

1. step: Igelite-Magnetite mixture:

Filtering in an air stream, three fractions. Efficiency: about 80% fine material. The rest of less fine particles is retransferred to the process, so that the overall efficiency is 95 - 97%

2. step: Igelite-Magnetite mixture, filtered (ca 58 - 61% Magnetite)

Addition of IG-wax E, Stabilisator C, regulation to a Magnetite content of 50%, mixing for 3 - 4 hours, finally filtering.

3. step: Rolling-mixture, filtered (50% Magnetite)

Rolling with a pre-roll. Rolling to a film at 180° C. Luvitherming on an expanding machine at ca 260° C.

4. step: Magnetophon tape blocks, type L

(per block 1000 m.)

Cutting in tapes of 6,5 mm. width and re-rolling.

5. Step: Magnetophon tapes, type L

(per tape ca 500 g)

Electromagnetic testing, confectionning (addition of bobbies etc. and packing).

6. step: Commercial ware, type L

Efficiency and Capacity

The table below gives an idea about the efficiency. Losses are due to rolling and to luvitherming (about 5 - 10%), the rest is connected with the cutting and rerolling process.

Mgt.tapes type L	Cut tapes	Tapes in block	Magne-therm	Roll-ing mix-ture	IG-Mgn. mixture filter-ed ca 50% kg	Mix-ture unfilt-ered 55% kg	Magn. tape type L
pieces	pieces	pieces	kg	kg	kg	kg	kg
100	131	145	72,5	80	70,3	73,8	50
76	100	111	55,5	61	53,6	56,3	38
68	90	100	50,0	55	48,3	50,7	34
136	180	200	100,0	110	96,5	101,3	68
124	164	182	91,0	100	87,8	92,2	62
142	187	208	104,0	114	100,0	105,0	71
134	177	197	96,5	108	95,0	100,0	67
200	262	292	146,0	160	141,0	149,0	100

Weight of the tape: ca 500 g per roll

Capacity:

Per day: 700 kg rolling mixture = 868 tapes

Within a 20 days working period: 14,000 kg rolling mixture = 17,360 tapes.

With a higher speed, the volume can still be raised without reducing the quality of the tapes. Therefore a maximum production of 20,000 commercial tapes per month could be realised.

Requirements for raw materials for 10,000 tapes, type L

According to the efficiency table, the following material is needed:-

Magnetite	4,000 kg
Igelite PCU	3,868 "
IG-wax E	120 "
Stabilisator C	12 "
Mixture	8,000 kg

Furnishers: Ludwigshafen till February 1945

On account of a bombardment, the whole aggregate, consisting of pre-rolling machine, calander and luvitherming installation was brought to Gendorf near Munich, where it has been repaired. Besides that, similar installations are available in Troisdorf (near Köln), Folienfabrik Fürth-Forchheim (near Nürnberg) and in Eilenburg (Saxonia), but with these installations, till now only insulating-luvitherm films have been produced.

The cutting machines and the re-rolling devices, as well as the whole confectionning accessories were transported to Wild-Michelbach.

III - Magnetophon tape Type LG

Magnetophon tape type LG is a two-layer film as the type C with the difference, that type LG bases upon Luvitherm. The basic layer is a Luvitherm film (G 40), coloured with Titane white. While for type C the basic and magnetisable layers are made on the coating machine in one single coating process, there are required two separate processes for type LG which are:-

(a) the fabrication of the titane-white coloured basic layer with "calander" and stretching roll.

(b) the coating of the Magnetite layer upon the basic film.

(a) The basic film : Luvitherm G 40

Basic material required: Igelite PCU, type GH for L
IG - wax E
Stabilisator C
Titane white extra T

Igelite PCU type GH for L)
IG-wax E) see under II
Stabilisator C)

Titane white T

Chemical character: Titane dioxyde

Application: 2% of it mixed witn Igelite PCU to colour the elsewese glass clear basic film for better distinguishing the sensitive side of the Magnetophon tape.

Furnisher: Leverkusen.

Fabrication of the basic layer see scheme of process

(b) Magnetite layer

Original material: Vinoflex MP 400
Magnetite, sifted
Plastomoll TAH
Solution medium E 13 N

Vinoflex MP 400

Chemical character: Mixed polymerisate from vinylchlorid and vinylisobutylaether at a proportion of 3 : 1.

Preparation: Vinylchlorid (furnisher: Schkopau or Rheinfelden) and vinylisobutylether (furnisher: Ludwigshafen) are polymerised at the presence of an emulgating medium with a certain pH-addition by phosphate at 55°C.

Properties: Pure white, granulated powder.

Application: As a medium for enclosing and fastening of the Magnetite

Furnisher: Ludwigshafen.

Magnetite, filtered:

see under Magnetophon tape type L (11)

Plastomoll TAH:

Chemical character: Ester of µµ tniodibutter acid with aethyhexanole. Esterfying of µµ thiodibutter acid and aethylhexanole according to usual methods with sulfuric acid as a catalisator.

Properties: Yellow coloured, heavy boiling liquid. Boiling point 230 - 297° C/20 mm. Hg.

Application: 4% of it added to the vinoflex MP-400 Magnetite mixture as smoother.

Furnisher: Ludwigshafen

Solution medium E 13 N:

Chemical character: Mixture of 17,5 parts metnanol, 30 parts aethylacetate and 52,5 parts of methylacetate.

Application: Attenuating and plastifying medium for the production of the rolling mass

Furnisher: Höchst.

Production of the roller mass see scheme of process

The coating dispersion:

Original materials: Rolling mass (see above)
Tetrahydrofuran
Benzole

Tetrahydrofuran:

Chemical character: 4 x hydrated furane

Preparation: Acetylene and formaldehyd are turned to butindiol, which is hydrated to butanediol. The watery butanediol is turned to tetrahydrofurane at a pressure of 100 atm. and a temperature of 300° C with phosphor acide as a catalisator and distilled.

Properties: Usual solvent with very good solving ability. Boiling point 65° C, poisonous.

Application: Solvent for vinoflex MP 400.

Furnisher: Ludwigshafen.

Benzole

Application: In a mixture with tetrahydrofurane as solvent for vinoflex MP 400

Furnisher: Benzolverband

Production of the coating dispersion
see scheme of process
Scheme of Process

a) Basic layer

Igelite PCU type GH for L: 95%
IG-wax E: 3%
Titane white extra T: 2%

Rolling on pre-roller and calander at about 180°C. Luvitherming on heated stretching roller.

Basic Layer (= Luvitherm G40
G40 = stretched,
0,04 mm.thick)

b) Rolling mass:

Vinoflex MP 400: 20%
Magnetite: 76%
Plastomoll:TAH: 4%
Solvent E 13 N (as required)

Knead one hour, subsequently roll 10 times.

Rolling Mass

c) Coating dispersion:

Rolling Mass
20 parts rolling mass in 7,5 parts of tetrahydrofurane and 5 parts benzole stir in a closed kettle for 36 hours and filter through a 10,000 meshed sieve

Coating dispersion

d) Production of the tape:

Coating dispersion (c) on basic layer (a). Coat over, dry, wind up (see for apparatus)

Magnetophon tape blocks type LG

Cut out and re-roll.

Magnetophon tapes type LG

Test, confectionate:

Commercial ware, type LG

Apparatus:

The coating machine was constructed by the IG/ Ludwigshafen and built according to experiments in the laboratories and set up in Aschbach/Odenwald.

The most essential part of the coating machine is a pneumatic pulling table through which the coated tape is taken with by means of a vacuum immediately behind the coating place by an endless transportation band running over rolls. Thus the basic tape coated with dispersion, which swells by the solvent and becomes stretchable, is exposed to a short times stretching load only in a humid state. To get a plain surface of the basic tape below the coating device it is fixed over the topline of a rotating roller.

The thickness of the coated layer upon the dried tape amounts to 0,010 - 0,015 mm. The drying is firstly made on a path of three meters length at room temperature, adjoining in a drying-cupboard at 23 - 25° C by circulating air.

Capacity:

Duration of coating: 5 hours per 1000 m.
in 24 " 3000 m. = 3 rolls
1 roll represents about 30 tapes.
Production a day: ca 90 tapes
Production a month: about 2700 tapes type LG

General properties of the types C, L & LG

The three types of tape C, L, LG have a width of 6,5 mm and a length of 1000 meters at a thickness of 0,045 - 0,05 mm.

The 1000 meter tape gives a space of 20 minutes time for recording and for reproducing. Therefore the tape passes the magnetising head with a speed of about 80 cm/sec during reproduction.

All tapes give only little background noise compared with disc reproduction, infinitive reproducability without diminishing the quality of tone, very high frequency range (still more than 10,000 c/s) and compared with the steel wire no wiping of the high frequencies when stored.

Cutting and sticking as pleased.

The production of the tapes type C in an ever constant quality is difficult. The quality depends in a wide range upon the quality of the Cellite used and the nitro-cellulose, which are not constantly uniformly chemically pure as they are made of a natural material, the cellulose. In the facturing there are always great fluctuations of the magnetic properties. The great mechanic load often causes tape bursts. Also against crack loads the tapes partly are very sensitive in an uncontrollable manner. The sensibility against temperature between - 20° C and + 50° C is a good one. There are no symptoms of an influence of the time.

For a new use a recorded tape is well to be wiped, there is also practically no magnetising of neighbour-layers while being stored.

The production of tape type L is the most simple, shortest and most efficient of all three types. The gain of the production is very constant, as the basic products are no natural materials and can be made and tested as chemical pure.

The electromagnetic qualities are very high, as well as the tapes of this type have not any sensibility against temperature and time. But compared with type C they have above all a very high mechanic stability and are absolutely unbreakable.

The tapes of the most novel type LG were elaborated in a long lasting work. The manufacturing is not quite as simple as that of type L, whereas they satisfy the highest claims with reference to the reproducing, purity and absence of disturbance of sound and tune. The dynamic is about 10 till 12 db better than that of the other tapes, the frequency characteristics are almost straight lines and lie very close together. Their bursting stability is still much higher than with type L.

Besides that it is impossible to confound front and backside, as the backside is uncoated and white coloured by the admixture of oxide of titane. Also the backside can be written and marked with fat-pencils.

As a matter of fact the fabrication of this type is unobjectionable not before the last days, after the machine repeatedly had been worked up and better developed to warrant an unobjectionable working.

It is to be expected, that also at a continuous fabrication the good constant quality obtained until now will be guaranteed.

Sticking medium:

Sticking medium used for

Type C	Cohesan
Type L)	Cyclonexan
Type LG)	

Testing of the Tapes:

Two or three tapes are taken from all series of fabrication and tested concerning their magnetic properties It is tested:

1) Range of modulation

2) Sensibility at 1,000 c/s
5,000 c/s
8,000 c/s

3) Modulation level

4) Level of background noise

The difference between 3 and 4 is the dynamic. +)

5) Equability of the tape

Confectionning:

For selling and conveyance each tape is marked with a number of fabrication as a control number. A bobby, fitting for the tape plates of the device is put in and then the tape is packed up between two pasteboard discs in a pasteboard box or envelope.

30 tapes are placed into a conveyance box.

Development of the Magnetophon

Year (1 X - 30.IX)	Total delivery of tapes from IG/Ludwh. and Wolfen Km	Delivery of Magnetophon sets by AEG pieces
1939/40	9350	379
1940/41	6340	302
1941/42	21,200	870
1942/43	52,000	844
1943/44	86,000	937

+) Not quite correct from the physical point of view (The translator).

Types of Apparatus

As far as known last year the manufacturing of Magnetophon sets at the AEG Berlin extended to the following 5 types:

Soundrecorder	"b"	Apparatus with variable tape speed for the "Wehrmacht".
"	"c"	Portable knapsack apparatus with spring driven motor (recording only) for "Wehrmacht" and broadcasting.
"	"d"	Apparatus for reportage cars of "Wehrmacht" and broadcasting
"	"RE3"	Special apparatus for the Navy
"	"K7"	Apparatus for high quality music recording and reproducing for broadcasting.

Conveyance:
(see Appendix)

Statement of the stores of tapes and halfway products existing in Wald-Michelbach on July 9th, 1945

Magnetophon tapes type L about 6,000 km
among them ready for conveyance on July 10th 3,000 km

Magnetophon tapes type LG
Tapes ready ----
Raw material (white basic layer and rolling mass) for about 12,000 km.

(inclusively coil bobbies & packing material)

Signed: Dr.Pflaumer

APPENDIX II

(xxi)

RAT. 43

DOCUMENT G

THE A.E.G. MAGNETOPHON

MODEL K7

C O N T E N T S

January 1946

Translated from German text of the A.E.G.

I. PRINCIPLE OF OPERATION

When recording, the signal e.m.f's delivered by the pre-amplifier are fed via the recording equaliser-amplifier to the recording head, across the gap of which they produce an alternating magnetic field. This in turn induces in the tape, as it passes the head, a remanent magnetisation which induces in the reproducing head corresponding alternating e.m.f's. The e.m.f's are fed via the reproducing equaliser-amplifier to a monitoring amplifier and loudspeaker.

The chief novelty in the recording method in the K7 apparatus lies in the use of alternating current of super-audio frequency both for wiping and for premagnetisation, by which means a considerable improvement in quality of reproduction has been achieved by comparison with the earlier types in which direct current was normally used for both these purposes.

When recording, the tape first of all passes the wiping head, the strong alternating magnetic field of which magnetises the tape to saturation and thus obliterates any previous magnetisation which it may possess.

Since the tape, as it passes from the gap of the wiping head, experiences a gradually decreasing and alternating magnetic field, it leaves the head in a completely non-magnetic state and in this condition it reaches the recording head. In the absence of signal modulation, as well as during pauses in speech or music, the same process is repeated at the recording head, except that, on account of the narrower gap in the recording head, the rise and fall of the magnetic field must be more rapid. This necessitates a higher frequency for pre-magnetisation. As before, the tape leaves the head in a completely non-magnetic state, which explains the remarkably low level of background noise.

The audio frequency signals are superimposed on the high (super-audio) frequency in the recording head, causing a displacement of the null or working-point in sympathy with the audio frequency signals, which thus appear on the tape as remanent magnetisation.

The reproducing head then picks up the audio frequencies in the same manner as in the earlier d.c. types of machine.

II. TECHNICAL DESCRIPTION

The Magnetophon model K7 is normally supplied mounted in a box, because it is often required to be movable. When permanent installation is required, it can be mounted either on a table or on a rack or in a cabinet.

The complete equipment comprises four items:-

1 machine unit
2 amplifier unit, comprising frequency correcting amplifiers (equaliser-amplifiers), monitor amplifier and connectors.
3. loudspeaker
4 box containing auxiliary equipment.

In the case of permanent installations the apparatus can also be used in conjunction with existing amplifiers. The monitor amplifier, connectors and loudspeaker can then be omitted and the equaliser-amplifiers only, without mounting, are supplied. Similarly, item 4 can, if desired, be supplied without the moving coil microphone.

Machine Unit

This comprises the motors and other necessary parts for driving the tape, also the head assembly, switch and other operational controls.

The drive is effected by three motors. Commutator less eddy-current motors are used for driving both the right- and left-hand turntables, described respectively as 'wind' and 'rewind' motors, whilst a synchronous motor (the 'drive' motor) is used to draw the tape past the heads at a constant speed both when recording and reproducing. The tape is driven by passing between a hardened steel spindle and a rubber idler which is held pressed against the spindle. The tape speed is determined, both when recording and when reproducing, solely by the synchronous drive motor, and is constant. The drive motor is of adequate size, so that even with slight changes in mains voltage an absolutely steady speed is ensured. The function of the wind and rewind motors is to wind up the tape on the right and left turntables respectively.

When running forward (recording and reproducing) the wind motor causes the right hand turntable to wind up the tape fed to it by the drive motor, the rewind motor acting simply as a brake so as to ensure an even tension in the tape as it is fed to the head assembly. The speed of both wind and rewind motors changes, of course, as the size of the reels changes. The new method of construction of the eddy-current motors ensures an absolutely steady tension of the tape and freedom from jerks. There is no possibility of trouble due to wear or dirt, as occurred with the commutator motors in earlier equipments.

When running back, the left turntable is driven at a high speed while the right hand one is braked. The drive motor is idle since the rubber idler roller is switched to the rewind position.

The "forward/backward" switch permits a steady jerk-free transition from full speed backwards, to slow speed backwards, stop, slow speed forward and full speed forward, which is of value when searching for a particular spot in the tape. This additional facility provided in the K7 equipment will be particularly appreciated in cases when recordings have to be edited by cutting and rejoining.

All motors have magnet-controlled band brakes. The bands are specially wide and stable so as to give an increased useful life. The taking up of the brakes, which has to be undertaken frequently in the initial period of service of the apparatus, can be conveniently done by hand without removing the apparatus from its housing.

In order to check the accuracy of the tape speed, the right hand guide roller is provided with stroboscopic markings so that the tape speed can be checked independently of the drive motor.

A further facility which will be appreciated in operating the machine is the new type of tape indicator which is in the form of a clock and is driven from the right hand guide roller. The scale indicates elapsed minutes and seconds.

For linking tapes, with a 2-machine installation, as well as for synchronising with a cine film, a marking device is provided. Small paper tabs which can convey information either in writing or by colours, can, by means of this device, be attached to the tape as it goes past, either when recording or when reproducing. Since these tabs are slightly larger than the breadth of the tape, they project from the rolled spool and the marked places can be quickly spotted.

On the left hand side of the machine plate is a row of press buttons for "Record", "Reproduce", "Stop" and Rewind". There is a simple interlock to guard against unintentional operation of the "Record" button. Chokes and condensers are fitted to prevent any high frequency interference due to the operation of the buttons.

A mains switch and two fuses are provided in the supply to the machine so as to isolate the complete motor assembly from the mains. The connection of the machine unit to both equaliser-amplifiers is effected via terminal strips which are easily accessible from the front without dismantling the equipment.

The only novelty in the head assembly, which contains one wiping, one recording and one reproducing head, is considerably improved screening from stray hum fields.

In spite of this improved screening, the threading of the tapes is made easy and convenient by virtue of a suitable disposition and wide spacing of the component parts. Further, the head assembly is equipped with means to enable the tape to be disengaged from the heads for rewinding. If use is made of these means, as a regular practice, wear on the heads is considerably reduced.

The circuit connections to the head assembly are made via a blade connector and a specially screened terminal panel which is likewise readily accessible without the necessity for dismantling any parts. The connections to the head assembly can be exposed for inspection and testing, while the equipment is in operation, by the removal of a cover plate.

The Amplifier Unit

In order to obtain a frequency response which is uniform over a wide range of frequencies, the apparatus is provided with both a recording and a reproducing equaliser-amplifier. These, together with the monitoring amplifier, are built into a box.

The equaliser part of the equipment comprises the recording equaliser-amplifier, the reproducing equaliser-amplifier and the mains unit common to both. These three elements are assembled in a chassis, and each of them is separately connected, through a blade connector, to the chassis wiring.

The recording equaliser-amplifier is equipped with two valves type EF 12 and three type EF 14, and has three amplification stages. One valve generates wiping current at 40 kc/sec and another premagnetising current at 200 kc/sec.

A potentiometer for level adjustment is accessible from the front panel. An internal potentiometer is provided, for frequency response correction.

A meter mounted on the front panel enables wiping current, premagnetising current or modulation current to be read, according to the setting of an adjacent switch.

The reproducing equaliser-amplifier has two stages of amplification (EF 12) and its input is connected direct to the reproducing head. Two potentiometers, accessible from the front panel, serve for equalisation of level and for adjustment of frequency response. These adjustments are not intended to be used as volume control or as tone control but solely for equalisation of level when operating with more than one set of equipment and for compensating for slight differences in frequency response due for instance to differences between individual heads.

The mains unit uses a rectifying valve type EZ 12. On the front plate of the mains switch are mounted a fuse and a hum eliminator.

For microphone recording and for reproduction through headphones or loudspeakers, the supplementary or monitoring amplifier provided with the complete apparatus must be used, in accordance with the signal-voltage figures given in Section III.

III. ELECTRICAL & OTHER DATA

1. Dimensions & weights

	Dimensions (mm)	Weights (kg)
Machine Unit	580 x 370 x 345	42.5
Recording & Reproducing equaliser-amplifiers, and mains unit	520 x 133 x 320	?
Monitor amplifier	520 x 133 x 320	10.3
Connection Unit	520 x 66 x 320	?
Loudspeaker	475 x 270 x 500	14
Auxiliaries Box	520 x 326 x 230	14.3

2. Power Supply

230 v, 50 c/s, 250 watts (approx.) as follows:-

Machine Unit	165 watts
Equaliser Unit	31 "
Monitor amplifier	35 "
Loudspeaker	17 "
	248 watts

3. Tape

Speed	77 cm/sec.
Duration of reel	20 minutes approx.
Length of reel	1000 metres
Breadth of tape	6.5 mm.
Thickness of tape	0.05 mm.
Tensile strength of tape	1 kg.
Dimensions of reel	280 mm. dia. x 10 mm. high
Dimensions of reel with packing	305 x 305 x 20 mm.
Weight of tape & packing	1 kg. approx.

4. Impedances & Levels

(a) Recording:

Input impedance	- equaliser	200 ohms
	- amplifier	200 "
Input voltage for full modulation	- equaliser	1.5 v.
	- amplifier	0.1 v - 10 mV.

(b) Reproducing

Load impedance at output of equaliser		200 ohms
Output impedance	- amplifier	15 "
" voltage	- equaliser	40 mV
	- amplifier	4 v.
" power	- amplifier	4 watts

5. Overall Performance

Frequency response from recording equaliser-amplifier via. the tape to the reproducing equaliser-amplifier	50 - 10,000 c/s ± 2 db
Signal/noise ratio	50 db
Peak signal/noise ratio (using aural sensitivity network)	60 db
Distortion at 1000 c/s	3%

Note: Equaliser inputs and outputs are symmetrical and non-earthy: the monitor amplifier has one side earthy.

APPENDIX III

(xxix)

RAT. 43

DOCUMENT L

DESCRIPTION OF THE MAGNETOPHON TYPES K4, HTS & K7

Translated from German text of the

A.E.G., 150 Hohenzollerndamm, Berlin

January 1946

Description of the Magnetophon Types K4, HTS & K7:

All three types of apparatus are used for the recording and reproduction of sound. In the case of the Type K4 equipment, wiping and premagnetising are effected by direct current, whilst in the case of the HTS and K7 types these operations are performed by high frequency current.

Type K4

In the K4, the machine unit is driven by three motors. Two of these drive the turntables to which the spools of tape are fixed, and are series-connected commutator motors. One of these (forward winding motor) drives the right-hand turntable and the other (rewinding motor) the left-hand turntable. The third, a single-phase condenser motor, is described as the main driving motor, its function being to convey the tape at a constant speed past the appropriate magnetic system both when recording and when reproducing.

The wiping of the tape is effected by direct current which is generated in the mains unit associated with the machine unit. The premagnetising current for the recording head is likewise derived from this mains unit. The value of the premagnetising current is indicated on a meter mounted on the front panel. An adjacent potentiometer (with screw-driver adjustment) enables the premagnetising current to be regulated to the prescribed value.

A set of four push-button controls is provided, as follows:-

(1) Record
(2) Reproduce
(3) Rewind (high speed)
(4) Stop

The tape can be made to travel at high speed in the forward direction by simultaneous operation of the "rewind" and "stop" buttons.

The complete K4 comprises the following parts:-

1. Machine Unit containing the recording equaliser which has no valves, the reproducing equaliser which is equipped with two valves type EF 12 and the mains unit common to both.

2. Linear Amplifier type V4, having an input unit which is adjustable to suit different source conditions. This unit has four pairs of input plugs for 60, 200, 10,000 and 50,000 ohms. respectively. A modulation meter indicating peak values is provided.

3. Moving Coil Loudspeaker with its own rectifier

The V4 amplifier can be dispensed with if an alternative amplifier is available, and the same applies to the loudspeaker.

Type HTS

The HTS is an intermediate type between the K4 and K7. It is intended for use in conjunction with existing auxiliary amplifiers and comprises the following two parts:-

1. Machine Unit, similar in construction to that of the K4 except that a synchronous motor is employed instead of the single-phase condenser motor. An absolutely steady rate of travel of the tape past the magnetic system is thereby assured. In contradistinction to the K4, the wiping and premagnetising currents fed to the magnetic system are high frequency currents and are generated in the equaliser unit described in greater detail under 2.

2. Equaliser & high frequency generator unit, comprising (a) a unit containing three valves type EL 11 which is in part the recording equaliser and also generates the high frequency wiping and premagnetising current

(b) the reproducing equaliser equipped with two valves type EF 12

(c) the mains unit common to (a) and (b) equipped with one valve type EZ 12.

The value of the wiping, premagnetising and modulation currents can be read on a meter mounted on the front panel of the recording equaliser.

Type K7

The K7 embodies a number of improvements based on experience gained with the HTS.

The complete K7 comprises the following four parts:-

1. Machine Unit in which two brushless eddy current motors are employed, instead of the commutator type motors used in the K4 and the HFS, to drive the turntables. The main driving motor is a synchronous motor, as in the case of the HFS. This arrangement ensures an absolutely constant speed and steady travel of the tape, and is not subject to troubles due to wear and dirt, such as occur with motors of the commutator type.

The motor band brakes working on the servo principle are particularly generously dimensioned and of sturdy construction, and consequently of long life. They are adjustable by hand, without the use of special implements, and without removing them from the casing..

The push-button control affords greater convenience of operation than that provided in the earlier types. A control switch marked "Vor - und Rucklauf" (forward and reverse running) provides for a smooth transition from high speed forward, through slow speed forward, stop, to slow speed reverse and on to high speed reverse, and vice versa, as an aid to locating a desired point on the tape. This arrangement is extremely useful when editing and cutting tape.

A stroboscopic device associated with the right-hand pressure roller enables a running check to be kept on the speed of the tape. The neon lamp in front of the stroboscopic pattern serves at the same time as mains voltage indicator.

All switches are equipped with interference suppressors to eliminate high frequency interference.

A novel type of tape meter is also provided and enhances still further the ease of operation. It is in the form of a clock, the dial being marked off in minutes and seconds. The pointer moves clockwise when the tape travels forwards and anti-clockwise when the tape motion is reversed. The meter is manually adjustable to zero irrespective of the position of the tape.

For cueing purposes, when making a changeover from one machine to another, provision is made for marking any desired point on the tape. For this purpose, small paper tabs, which can convey information either in writing or by colours, can be attached to the tape while in motion during recording or reproduction. The tabs are wider than the tape and consequently project above the surface of the wound tape spool.

The head assembly comprising the magnetic system is provided, in this type, with very considerably improved screening against magnetic hum fields. Nevertheless, the dimensioning and spacing of the screening is such that insertion of the tape is made easier rather than more difficult. An additional device is provided to enable the tape to be disengaged from the heads during rewinding, in order to save wear on these.

In order to enable the requisite operational checks to be carried out directly at the heads, their leads are taken to a specially screened terminal panel. After removal of a covering plate, tests and measurements can be carried out while the apparatus is in operation.

2. Amplifier Unit, comprising recording and reproducing equalisers with mains unit, monitoring amplifier and connecting strip. The equaliser system and the monitoring amplifier are each mounted in a separate chassis and are connected to the chassis wiring by blade connectors.

The recording equaliser (equipped with two valves type EF 12 and three type EF 14) contains also the electrical equipment for generating the high frequency wiping and premagnetising currents. A potentiometer, for level adjustment, is accessible from the front panel.

The reproducing equaliser has two amplifying stages (two valves type EF 12). Two potentiometers mounted on the front panel serve for level equalisation (balancing) and for frequency correction, when using two or more equipments.

The mainsunit uses a rectifier valve type EZ 12. Attached to the front panel are a mains switch, fuses and a hum eliminator. A meter, likewise mounted on the front panel, indicates wiping, premagnetising and modulation current, according to the setting of a switch.

3. Loudspeaker, similar in construction to that used in the K4.

4. Accessories box, containing tools and spares needed in handling the apparatus. Some spare reels of tape are also provided.

COMPARATIVE TECHNICAL DATA

	K4	HTS	K7
1. GENERAL			
Power supply required	220 volts, 50 c/s		
Overall frequency response, with tolerances	50-6,000 c/s ± 5 db	50-9,000 c/s ± 3 db	50-10,000 c/s ± 2 db
Mean signal/noise ratio (without aural sensitivity network)	-	-	50 db
Peak signal/noise ratio (with aural sensitivity network)	38 db	55 db	60 db
Distortion at 1,000 c/s	5%	4%	3%
2. MACHINE UNIT			
Power requirements	2/300 V.A.	165 w.	165 w.
Types of motor - (a) turntable motors	series, commutator	series, commutator	brushless, non-synchronous
(b) main drive motors	single phase, capacitor	synchronous	synchronous
Mains indicator	-	-	neon lamp
Mains switch	2-pole	2-pole	2-pole
Metering	Premagnetising current	-	-
Dimensions (closed)	475x470x325 mm.	600x360x350 mm.	580x370x350 mm.
Dimensions (open & with tape supporting plates in position)	640x470x325 mm.	640x420x350 mm.	640x420x350 mm.
Weight	57 kg.	45 kg.	42.5 kg.

	K4	HTS	K7
3. AMPLIFIER UNIT			
(a) Recording equaliser/ amplifier			
+ Input impedance	200 ohms	200 ohms	200 ohms
Input voltage for full modulation	1.5 v	1.5 v	1.5 v
Gain control	-	yes	yes
Frequency response control	-	yes	yes
Metering	-	Wiping, pre-magnetising & modulation current	wiping, pre-magnetising & modulation current
Valves	-	3 EL 11	2 EF 12 3 EF 14
Dimensions	(see ++ p.6)	500x120x205 mm.	(see ++ p.6)
Weight	"	8 kg.	"
(b) Reproducing equaliser/ amplifier			
Output impedance (separate output adapted for headphones)	200 ohms	200 ohms	200 ohms
Output voltage across 200 ohms	10 mV	30 mV	40 mV
Gain control	-	yes	yes
Frequency response control	-	yes	yes
Valves	2 EF 12	2 EF 12	2 EF 12
Dimensions	(see ++p.6)	500x120x205	(see ++ p.6)
Weight	"	8 kg	"

+ (Translator's note: There appears to be some doubt about the input impedance of the amplifier used in the HTS equipment. The RRG Technical Instruction Manual clearly shows this as 1500 ohms over the greater part of the frequency range.)

	K4	HFS	K7
(c) Mains Unit			
Power requirements	-	100 V.A.	100 V.A.
Fuses	-	600 mA	600 mA
Mains indicator	-	neon lamp	neonlamp
Switch	-	2-pole	2-pole
Valves	-	1 EZ 12	1 EZ 12
Dimensions	(see ++ below)	500x120x205 mm	(see ++ below)
Weight	"	13.5 kg	"
++ Dimensions	(a)+(b)+(c) 355x240x330 mm.	(see under individual units)	(a)+(b)+(c) 560x365x400 mm.
++ Weight	18 kg	"	35 kg. approx:
(d) Monitoring Amplifier			
Power requirements	65 watts	-	35 watts
Input impedance	60,200, 10,000 or 50,000 ohms	-	200 ohms
Input voltage	0.5 mV, 0.5 mV 100 mV or 2 V.	- -	0.1 - 10 mV
Output impedance (separate output adapted for headphones)	15 ohms	-	15 ohms
Output voltage	4 V.	-	4 V
Output power	2 watts	-	2 watts
Tone control	top dip	-	(i) bass dip when recording (ii) bass lift when reproducing (iii) top dip when reproducing.

	K4	HTS	K7
Valve	1 each - AF7 AH1 AL4 AZ1	-	1 each - AF7 AH1 AL4 AZ1
Switch	2-pole	-	2-pole
Metering	peak meter	-	peak meter
4. LOUDSPEAKER			
Dimensions	470x260x500 mm.	-	470x260x500 mm.
Weights	14 kg (approx)	-	14 kg (approx)
5. ACCESSORIES CABINET			
Dimensions	-	-	520x326x230 mm.
Weights	-	-	14.5 kg (approx.)

APPENDIX IV

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RAT 43

DOCUMENT P

THE MAGNETOPHON,

its properties and fields of use.

This is a paper written by Dr. Hans Joachim von Braunmuhl, dated June 10th 1945. He gave his location at that time as Speinshart, near Eschenbach, Oberpfalz and addressed the paper to the appropriate authority in the U.S. Occupying Forces. The original was in German, the attached being a translation by J. G. Arengo-Jones and M. J. L. Pulling, BBC.

January 1946

The Magnetophon, its properties and fields of use.

The Magnetophon is a modern magnetic sound recording device which uses as recording medium a narrow thin tape on which the sound frequencies are recorded magnetically by means of a ring-shaped recording head. The magnetisation thus produced in the tape can then be picked up by means of a similar ring-shaped reproducing head and reproduced as many times as desired.

Technicians were already at work on the magnetic recording of sound as early as 1900. The names of Poulsen, Stille and Blattner may be mentioned. They used as recording medium a steel wire and later a narrow steel tape. The apparatus thus produced was adapted for various purposes. A considerable improvement in quality was later achieved, so that the BBC, for example, used the "Blattnerphone" to a large extent in their radio programmes. According to publications available in Germany the U.S.A., in particular the Bell Laboratories, have recently reverted to magnetic sound recording and have achieved considerable success using both steel tape and thin steel wire. The American developments apparently have as their object the production of transportable equipment with a long playing time.

By contrast to the equipment just mentioned, instead of a relatively heavy steel wire or tape, the Magnetophon uses as recording medium a tape which is thin, light, reasonably strong, easily cut and rejoined, fireproof and cheap to manufacture. Such a recording medium, whose properties, as will be shown below, have a decisive influence on the construction and operation of the apparatus, has a noteworthy advantage over both steel wire and steel tape.

The Magnetophon in its original form was developed by the AEG of Berlin and was put on the market some years before the war. It was mainly thought of as a dictating machine and was accordingly provided with the facilities necessary for that purpose. The tape recording medium, whose characteristics are defined in basic patents by Pfleumer, was developed and produced by I. G. Farben Industrie at Ludwigshafen. +

This state of affairs led naturally to a close collaboration between AEG and IG which during the war resulted in the formation of the firm Magnetophon GmbH, 39 Karl Strasse, Berlin.

Although the Magnetophon, as already mentioned, was designed primarily as a dictating machine and was equivalent

in terms of quality to an average gramophone record, the method had so many basic advantages, even by comparison with gramophone records, that consideration was given to its use for other purposes as well. The credit for giving a considerable impulse at this juncture belongs to the Technical Department of the RRG (Reichs Rundfunk Gesellschaft) as being the part of the German Broadcasting organisation responsible for technical developments and their applications. ++

Within the RRG organisation the Research Laboratory, under the direction of the author, took an ever increasing interest in the Magnetophon and adapted it to the varied requirements of Broadcasting.

+ (Later, the AGFA Company of Wolfen near Bitterfeld, under the direction of Prof. D. Eggert, participated in this work with considerable benefit to the production of the tape.)

++ (It should be realised that the technical responsibility of the RRG was restricted to the chain of equipment from microphone to the input of the lines going to the transmitters, whilst the German Post Office managed the line distribution network and the radio transmitters.)

In the course of this work, which occupied a steadily growing proportion of the laboratory, the undersigned succeeded, in collaboration with Dr. Walther Weber, since deceased, in inventing a fundamental improvement in the magnetic recording process. This improvement consisted in causing the audio-frequency modulation current to act upon the recording medium simultaneously with high frequency alternating current, during the recording process. The success of this expedient was quite astonishing in regard to extension of the frequency range, to reduction of non-linear distortion, and, in particular, to elimination of background noise. The invention was at once made the subject of appropriate patent applications filed in the names of Dr. von Braunmuhl and Dr. Weber. The inventors, with the consent of the RRG, concluded a royalty agreement with the AEG, in respect of their patent applications, which in the meantime had increased to fourteen in number, and in respect of further collaboration with the manufacturing firm. +

The great improvement thus effected at one stroke led to the large scale adoption of the new process throughout the RRG, in the middle of the war. Up to that time, the RRG had relied mainly on discs for recording purposes; they were

largely displaced, however, by the Magnetophon in a remarkably short space of time, in spite of the obstacles to conversion resulting from wartime conditions. From then on, the Magnetophon was used in the great majority of all transmissions, In fact, it was used so extensively that even parts of programmes that could perfectly well have been done 'live' were, as a regular practice, recorded on Magnetophon tape and fed therefrom to the transmitters, for reasons of convenience or for other reasons. This practice resulted of course in the building up of an extensive archive of programme material offering a very wide choice of matter for repetition purposes.

The undersigned, who occupied a responsible position in the RRG from the year of its inception, 1929, onwards, does not remember any technical advance being greeted with such enthusiasm as the Magnetophon. The reason is to be found in the high quality of reproduction and the ease of handling peculiar to the Magnetophon. The quality of reproduction achieved is indeed so high that there is no appreciable difference as compared with direct transmission. Even when a direct and instantaneous comparison is made between a 'live' programme, and the same programme heard via the Magnetophon recording and reproducing system, a practised ear can detect no difference in quality. Consequently, it was justifiable to regard a Magnetophon recording as a fully equivalent substitute for a live transmission. The quantity of Magnetophon tape used by the RRG accordingly rose to 5000 kilometres per month.

The high frequency Magnetophon thus represents a novel sound recorder capable of meeting the highest demands and of competing in the first instance with the disc method previously used by the RRG as well as with other known high-grade recording methods, the foremost of which are the steel tape method, the photographic film method and the Philips-Miller system. Purely from the point of view of quality, comparison with these methods gives the following data:-

+ (Foreign applications were filed in most countries, claiming the Convention date of the corresponding original applications in Germany.)

In the stationary sets, the Magnetophon has a tape speed of 77 cm/sec, and with high frequency recording there is no difficulty in covering the frequency range with which broadcasting is concerned, namely up to 10,000 cycles per sec. It is, however, in principle quite possible to extend this frequency range up to 20,000 c/s and beyond, as has actually been done (Claims of this nature were made, about

the year 1934, by competent American authors, in respect of high quality stereophonic sound reproduction, also for sound film purposes).

It has proved possible, with the Magnetophon, to reduce background noise to - 60 db. relative to peak modulation. This means that the disturbance voltage amounts to only $\frac{1\text{th}}{1000}$ of the effective voltage and is therefore imperceptible even in critical musical passages and in periods of silence. In arriving at these data a value is adopted for admissible non-linear distortion which corresponds to the accepted requirements for high quality reproduction.

By contrast, the average commercial disc, in conjunction with one of the usual types of pickup, has a frequency range up to about 5,000 c/s and a dynamic range of at the most 40 db. This means that the needle noise amounts to at least 1/100 of the effective modulation, that is to say the voltage is ten times as great as in the case of the high-frequency Magnetophon. (This difference of 1:10 is highly significant. It has been proved, by subjective observation, that a disturbance noise amounting to 1/100th of the effective modulation is felt to be unpleasant, while a reduction by a further factor of 10 brings about such complete freedon from noise that any further reduction of background noise is of no interest, even for the most exacting requirements).

For photographic film it is claimed that a frequency range up to about 8,000 c/s can be covered. Experience shows, however, that this value is seldom attained. Moreover, difficulties of a fundamental nature are encountered in any attempt to raise the upper frequency limit. Background noise also varies within wide limits, depending partly on the nature of the recording method used (push-pull recording, automatic ground noise reduction etc), but is probably, on an average, at best - 50 db.

Furthermore, optically scanned film is subject to rapidly increasing background noise, owing to mechanical scratching and the effects of dust. This drawback is completely eliminated in the Magnetophon method. It has been demonstrated that even after the thousandth playing, the background noise in reproduction from Magnetophon tape is not increased. The reason for this is simple and obvious; scratches, dust, etc. have no magnetic effect at all, and only magnetic particles can

have any influence on the reproducing head. Particles of magnetic matter are of course extremely rare.

A comparison with the Philips-Miller system leads to results similar to those described above in connection with photographic film. Some years ago, a very carefully prepared comparative test was carried out in the RRG laboratory between the high-frequency Magnetophon and a Philips-Miller apparatus which had been checked by experts from the firm of Philips, who also handled it during the test. For the purpose of the comparison, the same material was recorded on the two sets of apparatus simultaneously and in precisely similar conditions. The reproduction from the Magnetophon tape was indisputably the better.

The comparisons described above relate primarily to the physical properties of the various methods. From the point of view of practical use, a number of other considerations of a practical and economic nature are of decisive importance. It would be beyond the scope of the present paper to make a complete and exhaustive comparison in respect of all such considerations. The present study will therefore be limited to the characteristic features of the Magnetophon system. A technical expert will be able without difficulty to make the appropriate comparisons with other methods and systems.

The Magnetophon tape is light in weight (a thousand metres weighs about 500 gms), flexible, of adequate tensile strength, non-inflammable, insensitive to dust, fingerprints and the like. It is easily cut and can be stuck together with any ordinary adhesive; joins produce no sound in reproduction. The tape is cheap to produce (1 Pfennig per metre) and can easily be produced in quantity (particularly by the Luvitherm process). The only inherent disadvantage, for certain purposes, is that the magnetic record is invisible.

The Matnetophon apparatus, owing to the light weight of the tape, can be built with considerably lighter moving parts than comparable photographic film apparatus and does not need, as the latter does, light-proof enclosure of the recording elements.

The Magnetophon has the great advantage over photographic film, that no intermediate chemical treatment is required. The tape can be played immediately after or even during recording.

The recording and reproducing heads are subject to slight wear, their average working life being approximately 400 hours. The replacement of a worn head is an extremely simple operation.

Compared with discs, the Magnetophon method has all the advantages of any strip type recording system, particularly as regards duration of reproduction and the possibility of editing by cutting and joining together, a possibility which is ruled out in the case of discs. The cutting and sticking together of Magnetophon tape is particularly simple as compared with other methods using strip media. The most conclusive proof of the ease and reliability of operation of the Magnetophon equipment is that the RRG brought the high-frequency Magnetophon into service in the middle of the war and that it was generally operated by women after only a short period of training. It will have been noticed in foreign countries how few breakdowns occurred, although almost all transmissions, including the most complex and difficult programmes, were transmitted from Magnetophon tape.

Spheres of Application of the High-frequency Magnetophon

A. For broadcasting and related purposes, for which both stationary and portable sets may be required.

B. For the highest quality of reproduction, particularly when the stereophonic effect is required.

C. For talking pictures (picture-synchronised recording and reproduction).

D. As a substitute for discs in a wide range of uses.

A. Broadcasting:

As already outlined above, the major improvements in the Magnetophon were evolved in the laboratories of the RRG and this being so, it was natural that development took place along lines which took the requirements of broadcasting into account. It is not necessary to go into details. Suffice it to say that the quality of reproduction achieved is such as to provide a perfect substitute for live transmissions. The following uses therefore suggest themselves:

Recording orchestral or dramatic performances anywhere and at any time, i.e. without the necessity of bringing an orchestra or performers to the studio. Production centres could be set up, as in the film industry, in which a large number of recordings could be made and kept in reserve for use in broadcasting. Such production centres would be set up and equipped to suit the needs of the artists employed. The possibilities of development in this direction are unlimited and would lead to the functions of a broadcasting centre becoming reduced to those of a control room handling the recordings supplied from the production centres. All that would remain to be produced in other broadcasting studios would be topical and spoken matter.

Recordings could also be made in existing concert halls, theatres and the like, although in this case the special requirements of broadcasting would not always be satisfied so well as in the proposed production centres. Decisions in this matter would be left to artistic rather than technical advisers.

A further range of uses results from the possibility of making the Magnetophon apparatus in portable form. An appropriate design was worked out during the war by engineers of the RRG laboratories. A set was produced the dimensions of which are about half those of a military knapsack. This contained all the necessary equipment and required only a microphone and a box of batteries to make it ready for operation. In the interests of compactness, and in view of the fact that the demands in the matter of quality are not so great in the case of a miniature set, the tape speed was reduced to 18 - 25 cm/sec. In spite of this, with the high frequency method, there is still obtained an upper frequency limit in excess of 6,000 c/s and the background noise level corresponds to that achieved with the stationary sets. These data show that even the miniature set is greatly superior to the disc and particularly to the ultra-thin disc hitherto used for portable recording and reproducing apparatus. The record duration is 10 minutes (compared with 20 min. in the case of the stationary apparatus) and has proved fully adequate for all purposes for which a portable set is required. The use of two standard tape speeds (77 cm/sec. and 18 - 25 cm/sec.) is not in itself a disadvantage, and in fact corresponds to the conditions obtaining with sound films which are likewise produced for two speeds, the normal film speed of 90 ft/min. and the miniature film speed of about 36 ft/min. Records made on Magnetophon tape at different speeds can easily be combined for reproduction, by dubbing. Dubbing in this connection presents no additional difficulty, since dubbing represents the normal copying method.

B. Stereophonic reproduction:

It is one of the special advantages of the Magnetophon, that it can be used for obtaining stereophonic reproduction effects, and, moreover, without the necessity for any appreciable modification of the apparatus. Stereophonic reproduction is obtained by using two or more microphones placed in different positions in the recording studio and making a corresponding number of recordings on the same medium through separate recording channels. On reproduction, these sound tracks are scanned separately but simultaneously and fed, separately, to a corresponding number of appropriately placed loudspeakers. The result is a stereophonic effect which differs materially from that of single channel reproduction. Apart from incomparably greater richness of sound, a spatial effect is obtained and each sound appears to come from a certain direction as it would under conditions of direct listening. Experiments have been carried out in this field for the past ten years in America; publications in American scientific journals have testified to the astonishing improvement in reproduction obtained by it. The author had an opportunity of discussing personally with the conductor of the Philadelphia Orchestra, Dr. Leopold Stokowski, the details of the American experiments.

The high-frequency Magnetophon is particularly well suited for use in stereophonic reproduction. The technical requirements are extremely simple. It is merely necessary to substitute a dual head assembly for the normal recording head assembly, each half of which is supplied with the audio-frequency signals derived from one of the microphone channels. The same procedure is adopted for reproduction. It goes without saying that in order to obtain the full advantages of the Magnetophon method, even in single channel recording, but more still in connection with stereophonic recording, it is necessary to use loudspeakers of the highest quality. As a result of research quite independent of that carried out on the Magnetophon, most successful results were obtained by the engineering department of the RRG with a so-called "Broad-band" loudspeaker which represents a decisive advance on any known type. Details of this are outside the scope of the present paper.

The use of stereophonic recording enables a binaural effect to be obtained and thus to provide artistic reproduction of such high quality, that it can be regarded as a substitute for direct listening even by the most exacting audience. This was also the conclusion arrived at by the American investigators, led by Dr. Harvey Fletcher of the Bell Laboratories, in what has become known as the Philadelphia-

Washington experiment, in which an orchestral performance in Philadelphia was stereophonically reproduced in a concert hall in Washington, with very great success.

Two-channel reproduction in broadcasting would, of course, in present circumstances, involve considerable complications, since two carrier waves and two receiving sets would be required. This problem will, however, become soluble with the development of the technique of ultra-short waves and frequency modulation. But even now, stereophonic reproduction by Magnetophon is worth considering for the purpose of relaying a high quality musical performance to places where such performances are not normally available. Whilst it is theoretically possible to do this by feeding the modulation signals through cables of the requisite construction and high quality to the place where reproduction is required, this is undoubtedly more complicated and less economical than the method of using a tape recording at the place of reproduction.

Stereophonic reproduction will also introduce the Magnetophon to all places where orchestras have in fact played, but where no particular value is attached to the actual physical presence of the orchestras themselves, for instance in restaurants and cafes, dance halls and the like - that is to say, places where an appreciation of the music does not depend on the ability to watch the musician, or where the orchestra is in any case hidden from view. There is scope here immediately for stereophonic reproduction by Magnetophon.

The critical music-lover who at present has to make do with the inadequate quality of single channel reproduction from discs will also be highly interested in the artistic possibilities of stereophonic reproduction by Magnetophon. The far-reaching difference between ordinary reproduction and stereophonic reproduction must be heard to be properly appreciated.

The relatively high cost of recording rather than the cost of the tape which is cheap, suggests that it would be preferable to think of Magnetophon records as a commodity to be hired out rather than sold. The necessary organisation for that purpose would have to be created.

The AEG, as manufacturers of the Magnetophon, took a step in this direction in the latter years of the war by founding the "Tonband G.m.b.H", of Berlin, which also carried out copying on a commercial basis. Owing to the difficulties

created by the war, however, the general objects of the Tonband G.m.b.H. were not advanced beyond the initial stages. Even so, the quality of stereophonic Magnetophon recordings was so much superior to those obtained by all other available recording methods that the RRG regarded it as their duty, in recent years, to make recordings by this method, particularly of the masterpieces of classical music, to be kept for the benefit of future generations.

C. Talking Pictures:

At first it may appear to be a digression to propose the use of the high-frequency Magnetophon for producing the sound-track of talking pictures, since photographic film is necessary in any case for the picture record, so that it seems obviously advisable to record the sound photography also. Closer acquaintance with the practice of sound film technique reveals, however, that picture and sound are recorded, in moving picture production, in the first instance on separate films which are only at a later stage combined to form a single film. So long as the sound-track is not combined with the picture film, it is therefore perfectly practicable to employ a non-optical recording method for the sound-track. It is, in fact, advisable to do so provided that a recording method is available which is superior to photographic sound recording. Such a method is now available in the high-frequency Magnetophon.

It will be clear that for this purpose the Magnetophon needs certain modifications to adapt it to the conditions of sound film technique, for example the use of a wider tape with perforations, in order to ensure perfect synchronisation between picture and sound.

That there is a need for such development of existing practice is clear from the fact that in recent years the German sound film industry has been paying close attention to this very problem. In America experiments have also been carried out in this direction. In these latter experiments, high quality discs were used as the primary recording medium; this medium, however, has serious drawbacks when used in conjunction with a film type picture record, in particular in respect of editing and cutting.

D. Use in the home:

The advantages described above of the high-frequency

Magnetophon suggest the use of Magnetophon recordings as a substitute for gramophone records for private use. Its use would be limited to conditions in which a mains current supply is available. The Magnetophon would therefore not replace the gramophone for use, for instance, in the open air, on boats, excursions and the like. It is, however, becoming increasingly popular to obtain reproduction from discs with the aid of an electric pickup in conjunction with an existing wireless receiving set. For this purpose it would be easy to design a suitably inexpensive Magnetophon apparatus, more particularly since it would only beneedal for reproduction. The longer playing time obtainable would be of great advantage, particularly for reproducing serious music such as symphonies, and offers a great improvement on existing expedients for effecting the change-over from one disc to the next every four minutes.

Labelled commercial Magnetophon recordings could be distributed either for sale or for hire. It would also be possible to arrange for consumers to return unwanted recordings to an establishment where they could be wiped, used for fresh recordings or copied (to order) and returned to the owners. The handling of the reproducing apparatus would be as simple as that of existing miniature film cameras or projectors.

Copying:

Magnetic recordings cannot be duplicated mechanically, as in the case of discs, nor photographically as in the case of sound films, but can only be copied by dubbing. In view of the exceptionally high quality of Magnetophon recordings, however, this does not amount to a disadvantage. Experience has shown that the reproduction quality of a dubbed copy is indistinguishable from that of the original. The great advantage of dubbing is that a single parent machine can be coupled to any desired number of satellites, so that a large number of copies may be obtained in a single operation. The above-mentioned Tonband G.m.b.H. operated successfully for a long time with their original battery of five satellite equipments. It would also be perfectly possible to design a special multiple apparatus for producing copies by dubbing. Hitherto, however, there has been no call for such an apparatus.

Conclusions:

The work of developing the high-frequency Magnetophon, carried out by the RRG in collaboration with the AEG and the IG, can be regarded as completed in all essentials. That the process has been developed to the point of commercial maturity is proved by the fact that the German broadcasting

system has been making use of it in recent years, almost exclusively and on a very large scale. Its adoption resulted in a great improvement in the quality of transmission and a considerable expansion of programme production facilities.

The apparatus has proved to be reliable and convenient to operate. The novelty of the method entails the necessity for keeping a very close check on the manufacture of the equipment, on the production of the tape, the quality of the individual parts, and so on. It is also necessary to carry out further development, particularly in regard to accessories and simplification of operation.

The copying method is capable of being still further improved, particularly in the direction of greater economy.

The use of the high-frequency Magnetophon for sound films and for private use has hardly even begun.

There is, therefore, a great deal of technical work still to be done, to ensure that the Magnetophon shall be able to fulfil all the technical purposes which it is undoubtedly destined to fulfil, quite apart from the extensive organisation required for the following activities:-

Manufacture of the equipment
Manufacture of the tape
Production (artistic and technical)
Copying, and
Distribution

The undersigned submits this paper to the American authorities in occupied Germany in the expectation of arousing their interest in further development in the Magnetophon field. At the same time, as the actual inventor of the high-frequency Magnetophon in collaboration with a number of co-workers who were all active for a number of years as experts in this field, he begs to offer his services in connection with such further development.

(sgd) H. J. von Braunmuhl
10.6.45.

APPENDIX V

List A.

This is a catalogue of patents granted in respect of the Magnetophon and its associated tape, which is believed to be complete up to issue date June 3rd 1944.

List B.

This contains as much information as it has been possible to collect concerning additional applications, some of which may have resulted in the grant of patents.

The sources of the above information were as follows:-

(1) A patent file held by Dr. Schmidt, Patent Director of AEG, at 150 Hohenzollerndamm, Berlin (British Sector), from which most of the information contained in List A was obtained.

(2) A damaged file held by Dr. Schepelmann of AEG, Hohe Bleichen, Hamburg (British Zone). This contributed some of the information given in List B.

(3) Information provided by Dr. H. J. Von Braunmuhl of Rundfunk Technische Zentralstelle, 11a, Kirdorfer Strasse, Bad Homburg, Nr. Frankfurt, U.S. Zone, which is embodied in List B.

LIST A: PATENTS ISSUED UP TO JUNE 3rd 1944

APPLICATION		FINAL				Patentee	Remarks and name(s) of Inventor(s)
No.	Date	No.	Date of Grant	Date of Issue	Class		
P.57028	31. 1.28	500900	5. 6.30	26. 6.30	42g	Fritz Pfleumer	British patent 333154
18cP60 30	3. 1.30	543563	21. 1.32	6. 2.32	18c	do.	do.
P.59323	31. 1.28	544302	28. 1.32	17. 2.32	"	do.	do.
P.1020.30	27.11.30	552787	2. 6.32	17. 6.32	42g	do.	Addition to 500900.British patent 394810
P.63273	15. 6.31	563306	20.10.32	3.11.32	"	do.	" " 552787 do.
A.65575	6. 4.32	582761	3. 8.33	22. 8.33	"	A.E.G.	Emil Mechau. British patent application 28749/42
P.65285	7. 5.32	593878	15. 2.34	5. 3.34	"	Pfleumer	Addition to 500900
U.20091	20. 9.32	605152	18.10.34	5.11.34	"	A.E.G.	British patent 434477
P.64308	22.11.31	612489	4. 4.35	25. 4.35	"	do.	Pfleumer
P.66508	26.11.32	617796	8. 8.35	28. 8.35	"	do.	do.
M.121027	13. 9.32	621522	17.10.35	8.11.35	"	Dr.Erwin Meyer & Dr. Eduard Schuller	—
A.68101	24.12.32	622623	14.11.35	2.12.35	"	A.E.G.	Dipl.Ing.Richard Keller
A.74689	29.11.34	637642	8.10.36	2.11.36	"	do.	Pfleumer. British patent 468068
U.20445	17. 2.33	639096	12.11.36	28.11.36	"	Veronika Oexmann	
P.72879	17. 3.36	640809	24.12.36	15. 1.37	"	A.E.G.	Pfleumer
A.75346	15. 2.35	647386	17. 6.37	3. 7.37	"	do.	Dr.Theo Volk
P.68168	9. 9.33	649408	12. 8.37	23. 8.37	"	do.	Pfleumer
A.67871	1.12.32	649596	12. 8.37	28. 8.37	"	do.	Volk
A.76746	6. 8.35	650508	2. 9.37	24. 9.37	"	do.	Volk
P.66730	31.12.32	652453	14.10.37	30.10.37	"	do.	Pfleumer
A.73468	21. 6.34	652979	28.10.37	10.11.37	"	do.	British patent 456573

LIST A (continued)

APPLICATION		FINAL				Patentee	Remarks and name(s) of inventor(s)
No.	Date	No.	Date of Grant	Date of Issue	Class		
A.79912	21. 2.36	655017	16.12.37	6. 1.38	42g	A.E.G.	
M.122837	13. 9.32	656834	3. 2.38	16. 2.38	"	Meyer & Schuller	
A.72123	24.12.33	660377	28. 4.38	21. 5.38	"	A.E.G.	Schuller. In slightly different form, Austrian patent No.143240. British patent 429987
A.67561	30.10.32	663413	14. 7.38	5. 8.38	"	do.	Keller
U.20854	20. 9.33	663728	21. 7.38	12. 8.38	"	Oexmann	
A.67808	25.11.32	663974	28. 7.38	17. 8.38	"	A.E.G.	Volk & Keller. Addition to 663413
A.76658	27. 7.35	664759	18. 8.38	3. 9.38	"	do.	Dipl.Ing. Willi Patzschke. British patent 459035
A.81454	20.12.36	666535	29. 9.38	22.10.38	"	do.	Dipl.Ing.Heinz Lübeck
A.79347	8. 5.36	669857	8.12.38	5. 1.39	"	do.	Schuller
A.82069	19. 2.37	673134	23. 2.39	16. 3.39	"	do.	do.
A.79710	20. 6.36	673396	2. 3.39	21. 3.39	42p	do.	do.
I.55208	12. 6.36	675490	21. 4.39	10. 5.39	42g	I.G.Farben	In name of Dr.Erwin Lehrer, Ludwigshafen. British patent 466023
A.73446	19. 6.34	675789	27. 4.39	17. 5.39	"	A.E.G.	Schuller
A.83713	22. 7.37	676810	17. 5.39	12. 6.39	"	Eduard Untermann & Dipl.Ing. Hans Schiesser	
A.79479	24. 5.36	678306	15. 6.39	13. 7.39	"	A.E.G.	Patzschke & Dr.Ing.Max Nippold
A.80101	31. 7.36	682944	5.10.39	27.10.39	"	do.	Priority claimed for this by USA from date 1.8.35. British patent 463234
W.102858	10. 2.38	693664	20. 6.40	16. 7.40	"	Walter Weber	
A.83167	3. 6.37	694070	27. 6.40	25. 7.40	"	A.E.G.	Lübeck
A.87206	19. 6.38	696068	8. 8.40	10. 9.40	57a	do.	Schuller and Schiesser
A.87378	4. 3. 36	698140	3.10.40	2.11.40	42g	do.	Schuller

LIST A (continued)

APPLICATION		FINAL				Patentee	Remarks and name(s) of inventor(s)
No.	Date	No.	Date of Grant	Date of Issue	Class		
A.80906	29.10.36	700177	14.11.40	14.12.40	42g	A.E.G.	Lübeck. British patent 504932
A.80933	30.10.36	700178	14.11.40	14.12.40	"	do.	Schuller, Lübeck and Patzschke
I.62015	23. 7.38	700696	28.11.40	27.12.40	"	I.G.Farben	Dr.Friedrich Matthias
L.96317	24.11.38	702298	9. 1.41	4. 2.41	"	A.E.G.	Schuller
A.79312	6. 5.36	702345	9. 1.41	5. 2.41	"	do.	do.
A.79737	21. 6.36	702998	30. 1.41	25. 2.41	"	do.	do.
A.87896	25. 8.38	704042	20. 2.41	21. 3.41	"	do.	Rolf Muller-Ernesti. Addition to 698140
A.74920	22.12.34	709308	3. 7.41	13. 8.41	74d	do.	Carl Braband
A.78716	4. 3.36	710594	7. 8.41	17. 9.41	42g	do.	Schuller British patent 2,230,913 290669 (?)
I.53076	23. 8.35	712457	25. 9.41	20.10.41	"	I.G.Farben	Dr.Rudolf Brill and Dr.Karl Schoenemann (Heidelberg)
A.75808	14. 4.35	712759	2.10.41	24.10.41	"	A.E.G.	Pfleumer
L.101384	25. 7.40	712825	2.10.41	27.10.41	"	do.	Ernst Koppler
L.97623	5. 4.39	713997	23.10.41	19.11.41	57a	do.	Schuller
L.98838	19. 8.39	714053	23.10.41	20.11.41	42g	do.	Untermann
B.190246	27. 3.40	714123	30.10.41	21.11.41	"	Dr.H.J.von Braunmühl & Dr.Walter Weber	
A.79751	24. 6.36	719546	12. 3.42	11. 4.42	"	A.E.G.	Schuller & Hans Westphal.Additional to 664759
A.87918	27. 8.38	721198	23. 4.42	29. 5.42	"	do.	Schuller
L.96366	27.11.38	723995	2. 7.42	15. 8.42	"	do.	Untermann
L.101112	27. 6.40	726723	10. 9.42	19.10.42	"	do.	Schuller
L.101088	18. 6.40	728149	15.10.42	20.11.42	57c	do.	Untermann

List A (continued)

APPLICATION		FINAL				Patentee	Remarks and name(s) of Inventor(s)
No.	Date	No.	Date of Grant	Date of Issue	Class		
A.81046	13.11.36	728719	29.10.42	3.12.42	42g	A.E.G.	Lübeck
L.103162	2. 2.41	730598	17.12.42	14. 1.43	"	do.	Schuller
L.101066	15. 6.40	730871	24.12.42	28. 1.43	"	do.	Schiesser
L.99968	24. 1.40	732592	4. 2.43	6. 3.43	57a	do.	Anton Sachsenmaier
L.104123	1. 5.41	733924	4. 3.43	5. 4.43	42g	do.	Lübeck
L.104829	10. 7.41	733925	4. 3.43	5. 4.43	"	do.	Muller-Ernesti
L.102741	15.12.40	735259	8. 4.43	11. 5.43	"	do.	Schuller
A.95037	1. 5.41	737090	27. 5.43	6. 7.43	"	do.	Schuller
B.196105	26.10.40	743186	28.10.43	20.12.43	"	von Braunmühl and Walter Weber	
A.62402	21. 6.31	743700	11.11.43	25. 2.44	"	A.E.G.	
L.102733	14.12.40	746041	23.12.43	3. 6.44	"	do.	Schuller

LIST B: PATENT APPLICATIONS, SOME OF WHICH HAVE BEEN GRANTED

APPLICATION		FINAL	
No.	Date	No.	Class
B.186470	28. 2.39		42g
B.186477	1. 3.39		"
L.101727	31. 8.40		"
L.102134	10.10.40		"
L.102699	1940		
B.191047	26. 6.40		42g
B.191304	27. 7.40	743411	"
B.191321	29. 7.40		57a
B.191690	3. 9.40		42g
B.191841	20. 9.40		"
B.192212	25.10.40		"
B.192221	26.10.40		57a
L.103047	1941		
?	1941	745587	
B.193741	27. 3.41		42g
B.193814	29. 3.41		"
B.194713	27. 6.41		"
B.195250	15. 8.41		"
B.196102	30. 9.41		"
L.108067	1942		"
B.197119	11. 2.42		"
B.197512	16. 3.42		"

APPENDIX VI

PARTS LIST FOR MAGNETOPHON MODEL K.7

(Reference Drawing AEG/AT/Mgt.403178N
Fig.19)

Circuit Ref.	Description of Part	
C 1	Tubular Condenser	0,1 uF/10/500 V.
C 2	Tubular Condenser	0,1 uF/10/500 V.
C 5	Tubular Condenser	0,1 uF/10/500 V.
C 6	Tubular Condenser	0,1 uF/10/500 V.
C 9	Tubular Condenser	0,1 uF/10/500 V.
C11	Paper Condenser	B 0,1 /700
C12	Paper Condenser	B 0,1 /700
C13	Condenser	
C14	Condenser	
C15	Condenser	
C16	Condenser	
C24	Electrolytic Condenser	10 uF/350/385 V.
C25	Electrolytic Condenser	25 uF 350/385 V.
C28	Paper Condenser	1000 /500
C29	Tubular Condenser	250 pF/20/500 V.
C30	Electrolytic Condenser	50 uF 6/8 V.
C31	Paper Condenser	B 0,5 /350
C32	Paper Condenser	B 4 /250
C33	Paper Condenser	0,05 /500
C34	Electrolytic Condenser	50 uF 6/8 V.
C35	Paper Condenser	2500 /500
C36	Paper Condenser	2500 /500
C37	Paper Condenser	B 4 /250
C38	Electrolytic Condenser	10 uF 250/275 V.
C39	Paper Condenser	500 /700
C42	Tubular Condenser	50 pF/20/500 V.
C45	Paper Condenser	1000 /500
C46	Electrolytic Condenser	250 uF 6/8 V.
C47	Paper Condenser	B 1 /250
C48	Paper Condenser	B 2 /250
C49	Paper Condenser	B 1 /160
C50	Paper Condenser	5000 /125
C51	Paper Condenser	1000 /500
C52	Electrolytic Condenser	5 uF 250/275 V.
C53	Electrolytic Condenser	250 uF 6/8 V.
C54	Paper Condenser	B 1 /250
C55	Paper Condenser	B0,25 /160
C56	Paper Condenser	B 1 /160
C57	Paper Condenser	B 1 /160

Circuit Ref.	Description of Part	
C58	Electrolytic Condenser	250 uF 30/35 V.
C59	Tubular Condenser	250 pF/20/500 V.
C60	Tubular Condenser	250 pF/20/500 V.
C61	Paper Condenser	1000 /500
C62	Paper Condenser	0,01 /250
C63	Paper Condenser	1000 /500
C64	Paper Condenser	2500 /500
C66	Electrolytic Condenser	25 uF 6/8 V.
C67	Condenser	
C71	Electrolytic Condenser	250 uF 6/8 V.
C72	Electrolytic Condenser	10 uF 100/110 V.
C73	Paper Condenser	B 2 /250
C74	Tubular Condenser	0,1 uF/10/500 V.
C75	Electrolytic Condenser	250 uF 12/15 V.
C76	Paper Condenser	B 0,2 /250
C77	Electrolytic Condenser	10 uF 30/35 V.
C78	Paper Condenser	B 2 /250
C79	Electrolytic Condenser	10 uF 350/385 V.
C80	Electrolytic Condenser	10 uF 350/385 V.
C81	Electrolytic Condenser	250 uF 12/15 V.
C82	Paper Condenser	B 1 /160
C83	Tubular Condenser	5000 pF/20/250 V.
C84	Tubular Condenser	0,1 uF/10/250 V.
Dr 1	Choke	EDB I 90 uH
Dr 2	Choke	EDB I 90 uH
Dr 3	Choke	EDB I 90 uH
Dr 4	Choke	EDB I 90 uH
Dr 5	Choke	EDB I 90 uH
Dr12	Choke Coil	
Dr15	Choke	2x2750 Wdg. 0,14 Cu.L.
Dr18	Choke	5200 Wdg. 0,06 Cu.L.
Dr19	Choke	1800 Wdg. 0,1 Cu.L.
Dr20	Choke	14000 Wdg. 0,07 Cu.L.
Dr24	Choke	1350 Wdg. 0,18 Cu.L.
Dr26	Choke	260 Wdg. 0,3 Cu.L.
Dr28	Mains Choke	
G1 1	Rectifier	
G1 2	Rectifier	
G1 3	Rectifier	
G1 5	Rectifier	
J 1	Meter	
J 2	Meter	

Circuit Ref.	Description of Part	
K 1	Wiping Head	
K 2	Recording Head	
K 3	Replay Head	
Ma1	Magnetic Brake for Main Motor	
Ma2	Magnetic Brake for Turntable Motor, left	
Ma3	Magnetic Brake for Turntable Motor, right	
Ma4	Magnetic Brake for Rubber Pressure Roll	
Mo1	Main Motor	
Mo2	Turntable Motor, left	
Mo3	Turntable Motor, right	
P 1	Adjustable Resistance	100 lb 2
P 3	Adjustable Resistance	500 k 2b 2
P 4	Adjustable Resistance	500 k 2b 2
P 6	Adjustable Resistance	1 M 2b 2
P 8	Adjustable Resistance	5 k lb 2
P11	Potentiometer	500 Ohm pos.log.
P12	Adjustable Resistance	1 k lb 2
R 1	Relay	
Ro1	Valve	EZ 12
Ro3	Valve	EF 12,02
Ro4	Valve	EF 12,02
Ro6	Valve	EF 12
Ro7	Valve	EF 12
Ro8	Valve	EF 14
Ro9	Valve	EF 14
Ro10	Valve	EF 14
Ro11	Indicator Lamp	
Ro12	Valve	AF 7
Ro13	Valve	AL 4
Ro14	Valve	Ah 1
Ro15	Valve	AZ 1
S 1	Switch (2-pole)	
S 2	Switch)	
S 2	Switch) Re-wind	
S 2	Switch)	
S 2	Switch - Record	
S 2	Switch - Replay	
S 3	Switch	

Circuit Ref.	Description of Part	
S 4	Switch (2-pole)	
S 6	Switch	
S 8	Switch	
S 9	Switch	
S10	Switch	
S11	Switch	
S11	Fuze	2,5/250
S12	Fuze	2,5/250
S13	Fuze	T 1/250
S15	Fuze (in U.13)	
S16	Fuze	1/250
U 1	Mains Transformer	
U 3	Input Transformer	
U 4	Output Transformer	
U 6	Input Transformer	
U 7	Output Transformer	
U 8	H.F. Transformer	
U 9	H.F. Transformer	
U11	Input Transformer	
U12	Output Transformer	
U13	Mains Transformer	
W 1	Resistance	0,25 W Da 100 Ohms 5
W 2	Resistance	0,25 W Da 100 Ohms 5
W 5	Resistance	0,25 W Da 100 Ohms 5
W 7	Resistance	0,25 W Da 100 Ohms 5
W 8	Resistance	250 Ohms 35 W
W 9	Resistance	200 Ohms 25 W
W10	Resistance	600 Ohms 25 W
W11	Resistance	600 Ohms 25 W
W12	Resistance	200 Ohms 25 W
W14	Resistance	1200 Ohms 25 W
W18	Resistance	300 Ohms 35 W
W19	Wirewound Resistance	0,5 W Da 4 Ohms 5
W22	Resistance	0,25 W Da 2 M.Ohms 5
W23	Resistance	0,25 W Da 50 k.Ohms 5
W24	Resistance	0,25 W Da 2 k.Ohms 5
W25	Resistance	0,25 W Da 300 k.Ohms 5
W26	Resistance	0,25 W Da 100 k.Ohms 5
W27	Resistance	0,25 W Da 20 k.Ohms 5
W28	Resistance	0,25 W Da 1 k.Ohms 5
W29	Resistance	0,5 W Da 20 k.Ohms 5
W30	Resistance	
W33	Resistance	0,25 W Da 500 k.Ohms 5
W34	Resistance	0,25 W Da 20 k.Ohms 5

Circuit Ref.	Description of Part	
W35	Resistance	0,25 W Da 1,25 k.Ohms 5
W36	Resistance	0,25 W Da 100 k.Ohms 5
W37	Resistance	0,25 W Da 300 k.Ohms 5
W38	Resistance	0,25 W Da 30 k.Ohms 5
W39	Resistance	0,25 W Da 100 k.Ohms 5
W40	Resistance	0,25 W Da 20 k.Ohms 5
W41	Resistance	0,25 W Da 2 k. Ohms 5
W43	Resistance	0,25 W Da 3 k. Ohms 5
W44	Resistance	0,25 W Da 200 k.Ohms 5
W45	Resistance	0,25 W Da 600 k.Ohms 5
W46	Resistance	0,25 W Da 30 k.Ohms 5
W47	Resistance	0,25 W Da 100 k.Ohms 5
W48	Resistance	0,25 W Da 10 k.Ohms 5
W49	Resistance	0,25 W Da 200 k.Ohms 5
W50	Resistance	0,25 W Da 200 k.Ohms 5
W51	Wirewound Resistance	2 W Da 400 Ohms 5
W52	Resistance	3,5 k. Ohms 35 W
W53	Resistance	0,25 W Da 50 Ohms 5
W54	Resistance	0,25 W Da 200 Ohms 5
W55	Resistance	0,25 W Da 200 Ohms 5
W56	Resistance	0,5 W Da 500 Ohms 5
W57	Resistance	0,5 W Da 500 Ohms 5
W58	Resistance	0,25 W Da 200 Ohms 5
W59	Wirewound Resistance	1 W Da 4 K. Ohms 5
W60	Wirewound Resistance	1 W Da 4 k. Ohms 5
W65	Resistance	0,25 W Da 10 k. Ohms 5
W66	Resistance	0,25 W Da 500 Ohms 5
W67	Resistance	0,25 W Da 200 k. Ohms 5
W68	Resistance	0,5 W Da 2,5 k.Ohms 5
W69	Wirewound Resistance	0,5 W Da 1 k. Ohms 5
W70	Resistance	0,5 W Da 80 k. Ohms 5
W71	Resistance	0,5 W Da 160 k.Ohms 5
W72	Resistance	0,5 W Da 30 k. Ohms 5
W73	Resistance	0,25 W Da 0,5 M.Ohms 5
W74	Resistance	0,5 W Da 3 k.Ohms 5
W75	Resistance	1 W Da 160 Ohms 5
W76	Resistance	0,25 W Da 40 k. Ohms 5
W77	Resistance	0,5 W Da 160 Ohms 5
W78	Resistance	1 W Da 6 k. Ohms 5
W79	Wirewound Resistance	6 W Da 30 k. Ohms 5
W80	Resistance	0,5 W Da 300 k. Ohms 5
W81	Resistance	0,25 W Da 5 k. Ohms 5
W82	Resistance	0,25 W Da 80 k. Ohms 5
W83	Resistance	0,5 W Da 100 Ohms 5
W84	Resistance	0,25 W Da 50 Ohms 5