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TEST GEAR FOR FREQUENCY MODULATION AND TELEVISION.

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

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F.D. 4/35/47. { 3 Photoprints relating to Frequency Modulation + Television (Siemens + Telefunken: Berlin

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TEST GEAR FOR FREQUENCY MODULATION AND TELEVISION

Reported by

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BIOS. Trip No: 2319.

BIOS. Target Numbers
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Summary

The report summarises the information gained by BIOS team No.2319 on German test gear for frequency modulation and television. The investigation was carried out during the period June 12th to July 8th, 1946, ten targets being visited. Other targets were considered but not investigated, either as the result of reports by other teams, or because they could not be located.

The only test equipment encountered designed specifically for frequency modulation were signal generators. One instrument developed by Telefunken was inspected, and circuit diagrams of three types being developed by Siemens Halske were obtained and discussed. None of these instruments show any outstanding features, the designs being sound but conventional. In addition, methods of modulation and demodulation of FM signals and laboratory methods of calibrating FM transmitters and receivers were discussed with German engineers; no information previously unknown to members of the team resulted from these discussions.

Little research work has been carried out in Germany on television during the war, apart from the application to war-time projects. One instrument encountered, which has been developed during the war, was a test oscillator with provision for swinging the frequency cyclically over a range of 8 Mc/s in order to delineate the frequency response of a receiver on a cathode ray tube. A description of the tests carried out by the Deutsche Reich Post and by commercial firms immediately prior to the war on television receivers was obtained.

1. Introduction

The object of BIOS trip No. 2319 was to investigate the progress made in Germany during the war period in connection with test gear for frequency modulation and television. General test equipment has been covered by many previous BIOS teams, but as little information has been obtained on the subject covered by this report it was considered desirable to send a team with this specific objective.

In addition, methods of modulating and demodulating FM signals and laboratory tests of FM and television equipment were discussed with German engineers in order to see how such methods might be embodied in test equipment.

Ten targets were visited during the period June 12th to July 8th and reports on these are given in §2. Other targets listed in §3 were considered but not visited for reasons stated therein.

Submission of the report has been delayed because one of the documents which it was requested should be evacuated has not been received (See Report VII). Unsuccessful attempts have been made to obtain this document, and it has now been decided to publish the report without it.

2. Report on Targets Visited

Report I — Siemens Halske, Berlin, Wernerwerke, Siemenstadt, British Sector

This target was visited on 13.6.46 and the following personnel interrogated:

Dr. Hoffman,	German Liaison Officer
Herr Ruf,	Section Leader
Herr Hagenhaus,	Development Engineer

The general condition of this target has been covered by previous BIOS teams, and will not be described in this report.

The only FM equipment under development by Siemens Halske in Berlin consisted of signal generators, and the location of these laboratory models was unknown. They were said to have been either destroyed or evacuated by the Russians. The work was directed by Dr. Buckman Thilo who was later transferred to Munich. The summarised performance information on these signal generators was

given, but no circuit diagrams were available. A later visit to Siemens Halske, Munich, confirmed this information and circuit diagrams were obtained there (See Report No. VIII).

No television test equipment has been developed by Siemens Halske. One rack of equipment for generating a test pattern had been supplied by Telefunken GmbH in 1939, but was evacuated by the Russians.

The engineers interrogated were co-operative, but had not been directly in touch with the work discussed. The only useful information obtained at this target was the advice to visit Siemens Halske, Munich, in order to obtain the required information on FM signal generators.

Report II Interrogation of Hans Roder, Berlin, 16.6.46

Roder was formerly a departmental head of Telefunken GmbH specialising in propagation studies, frequency modulation and the applications of radio frequency currents in industry. He is now working for the Russians in the communication laboratory at Berlin-Lichtenberg, Bahnhofstrasse 9 - 17. He was interrogated at his private address, Berlin Charlottenburg, Mommsenstrasse 10, III, which is in the British Sector.

Roder's work has previously been summarised in the Following SIGESO report:

COPY OF A REPORT BY Dr. HANS RODER ON TECHNICAL WORK IN GERMANY FROM DECEMBER 1938 to APRIL 1945.

The object of the visit was to obtain information on the test equipment, if any, used in Roder's FM tests. In addition the team was requested by G(T) and CW, Bad Oeynhausen, to obtain further information on Roder's experiments on two synchronised FM transmitters.

It was revealed that, in his FM experiments carried out during the early part of the war, conventional circuits for modulation and demodulation were used. No test equipment designed specifically for FM was available, laboratory methods of measuring the various quantities being used. The carrier peak deviation was measured, for instance, by combining the modulated carrier and a variable frequency oscillator in a mixer, and applying the rectified output to a cathode ray tube; the modulating frequency was applied to the other pair of plates. The resulting tube display consists of a broad band with a 'pip' superposed when the instantaneous carrier

frequency equals that of the fixed oscillator. By varying the frequency of the latter and moving the 'pip' from one end of the trace to the other the total carrier deviation could be measured. This method is well known, and is in any case not suitable for test equipment in which an instantaneous indication of deviation is required. Roder stated that his transmitting and receiving equipment was unsatisfactory in many ways, consisting of units which were designed for other work, and not specifically for the job. It is, therefore, not surprising to find that no test gear was available for these experiments.

Further information was sought on the operation of two synchronised FM transmitters, referred to in Roder's report. It appears that one of these transmitters was located at Europa Haus, Anhaldter Bahnhof, and the other at the Telefunken factory in Zehlendorf, both places being in Berlin. The approximate distance between the transmitters was 11.5 Km, the operating frequency of the order 40 Mc/s, and the peak deviation approximately $\pm$30 kc/s.

The transmitters were not synchronised in the accepted sense of the word. Each was controlled by a separate LC circuit, set to give the same nominal frequency; different modulations were used on the two transmitters. It was hoped to keep the two frequencies the same to within 500 c/s but this was never achieved. Roder was attempting to improve the oscillator stability when it was decided to discontinue these experiments.

Making a survey from one transmitter direct to the other, the disturbance range was said to be "remarkably small", 50 - 80 metres. Even within this range spots could be found where either one transmitter only or the other could be heard - possibly due to local variations in field strength caused by reflections from trees or telephone lines. Within the disturbance zone a combination of the two modulation signals, and distorted cross-modulation occurred; Roder seemed a little vague about the exact nature of the distortion.

Roder's statement on the disturbance zone must be accepted with some reserve, as so much depends on the criterion adopted to decide where a disturbance zone commences. Observers in America and England agree that a carrier ratio of the order of 20 - 30 db is necessary for common channel working to give results comparable with a single transmitter.

Roder also mentioned that Telefunken had built the Hamburg police FM Communication system and this was seen later in Hamburg but revealed only one minor point of interest (See Report V). He

also said that he had tried to stimulate interest in FM broadcasting on high frequencies during 1938, believing that this is the ultimate solution for high fidelity broadcasting using synchronised transmitters. He envisaged a series of stations serving the big towns, using FM because of its greater range and freedom from interference. The Deutsche Reich Post however was not very interested in the work and it was abandoned.

Roder seems to have tried to stir up an interest in the work he was doing and was evidently disappointed with the lack of interest shown. This may be one of the reasons why he attempted to resign in 1942.

Summarising Roder's work, it has not covered any ground which has not already been covered in Allied countries, and has neither provided new information nor utilised novel equipment.

Report III Telefunken GmbH, Berlin, Schoneberg, Maxstrasse 8.

Two visits were paid to the Telefunken factory on 14.6.46 and 17.6.46. The following personnel were interrogated:

Herr Muth	Section Leader
Dr. Franz	Section Leader

It was stated that the only equipment using frequency modulation made by Telefunken were the communication sets 'Michael' and 'Rudolf', types DMG5K and DMG3G respectively. These are multi-channel communication equipments working in the band 50 to 60 cms, in which subcarriers are amplitude modulated, the channels added, and the total modulation signal used to frequency modulate the carrier. Full operating instructions on these equipments are available in England.

Michael provided 1 speech and 2 telegraphy channels and Rudolf 9 carrier frequency speech channels, the peak frequency deviation being ±60 kc/s. Each speech channel can alternatively be used for 3 teleprinter channels.

In the transmitter a magnetron is used as the oscillator, and is anode modulated. The application of modulation causes changes in both amplitude and frequency of the carrier wave, the AM component being suppressed in the receiver, and the FM component used to convey the intelligence. The receivers employ a magnetron as a frequency changer, the I.F. frequency being 650 kc/s. In the Michael receiver, the discriminator consists of two circuits, one tuned above and the other below the mean I.F. frequency. The

differential D.C. output from this detector is also used automatically to control the local oscillator frequency. In the case of the Rudolf receiver, a single stage low pass filter section is used as the discriminator; the automatic frequency control is similar to that used in the Michael receiver.

These equipments were widely used for communication purposes during the war. For lining up purposes in the field the local transmitter was used as the source and a cathode ray tube unit connected to the output of the receiver discriminator, the other pair of plates being connected to the modulating signal. The receiver circuits were then adjusted to give the most linear trace on the screen.

For general laboratory F.M. tests a signal generator had been developed, and was seen on the occasion of the second visit, namely 17/6/46. A circuit diagram of the instrument, Wobbelsender 2.9 u 18 Mc/s, is attached, Fig. 1. The purpose of the generator is to produce a frequency modulated signal at either 2.9 or 18 Mc/s. This is achieved by using two oscillators on 7.55 and 10.45 Mc/s respectively, which are mixed, the difference or the sum frequency being selected by a switch as required. One oscillator can be frequency modulated, a conventional type of reactance valve modulator being used. The other oscillator is fixed in frequency, both oscillators being applied through separator stages to a mixer. The sum or difference frequency is selected by means of switched filter networks. This is then applied to an amplifying stage, giving alternative outputs of 0.5, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5} volts. Different concentric jacks are used for each output level, instead of a rotating switch as is usual in America and Great Britain.

Provision is made for amplitude modulation, frequency modulation at 50 c/s, by external modulation, or by both simultaneously. The latter arrangement was used to determine distortion in the receiver.

The frequency deviation is not measured directly, but the audio input level is indicated and the meter calibrated directly in terms of the deviation up to $\pm$100 kc/s; the meter was approximately linear except at the lower end of the scale. Presumably the meter is calibrated using D.C. modulation; it was stated during the visit that this deviation meter was operated from a calibrated discriminator, but this information does not agree with the circuit diagram received later.

A means was provided for checking the output frequency, but the exact way in which this was done is not clear from the circuit diagram. The purpose of the 50 kc/s oscillator incorporated in the instrument is also not apparent, but both these points are unimportant.

The equipment was battery operated (with the usual German multiplicity of supplies) in a steel screening box approximately 2' x 1' x 1'. Each unit was in a separate screened compartment, the design being neat and compact but not outstanding.

In discussing the general FM development programme carried out by Telefunken no mention was made at first of Roder's contribution, and on being questioned about this Muth first stated this was done entirely in America before the war, and later that it was entirely theoretical, both of which statements are incorrect.

No special test equipment has been developed for television, work on which was abandoned at the beginning of the war. Previous to this a special test pattern card, Siemenstarr, has been designed for checking the resolution of receivers, but the results were estimated entirely subjectively.

No mention was made of the rack of equipment loaned to Siemens Halske, Berlin (See Report I) and on questioning, no information was obtained except that it was probably just an artificial pattern generator and in any case was not a production job. Due to dispersal of staff it was claimed to be impossible to obtain further information on this equipment.

Summarising, this visit resulted only in information on one type of FM signal generator, and this shows no outstanding features. The personnel interrogated were not considered particularly co-operative, but from other enquiries made it is not considered that valuable information was being withheld.

Report IV Lorenz GmbH, Berlin, Lorenzweg 1, American Sector.

This target was visited on 17/6/46, and the following personnel interrogated:

Herr Saberski, German Liaison Officer.
Dr. Seidelbach, Section Leader.

The only work on frequency modulation carried out in Berlin consisted of laboratory tests of a general nature. No test equipment of any kind had been designed or produced, the parameters such as carrier frequency deviation and discriminator linearity having been checked by laboratory tests of a conventional type.

Tests on television receivers were also carried out using laboratory set-ups. Sets were tested up to a bandwidth of 4 Mc/s using rectangular pulse modulated signals, the shape of the pulse at the video output being compared with that of the input pulse.

Using the same type of signal, but employing a series of pulses of which the amplitude increases linearly with time, a gradation from black through grey to white can be obtained, as illustrated.

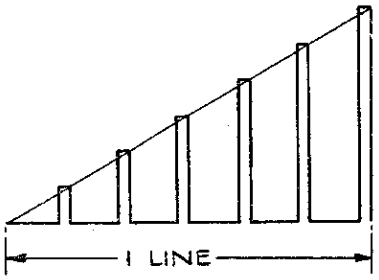


Fig. 2

This test, of course, checks only amplitude distortion in the receiver. If the results of these two tests were satisfactory it was considered that the receiver was satisfactory. However, an additional test pattern was used to check overall performance, the pattern consisting of black, grey and white squares.

No objective measurements on receiver resolving power have apparently been considered.

Summarising, no information was available on FM equipment. In the case of television the test involving a linearly increasing pulse amplitude is thought to be novel, and is considered useful.

Report V Hamburg FM Police Communication System, British Zone.

This communication system was designed by Telefunken GmbH and installed during the early war years. It was inspected as it was thought it would probably be typical of best German practice; the design was sufficiently recent to be of interest, but not late enough to be affected by wartime expedients.

The system is now under the control of

Control Commission for Germany,
Posts and Telecommunication Branch,
Reichpostdirektion,
Stephansplatz, Hamburg,

and was demonstrated by Captain Shears, on 21st June 1946 and 25th June 1946.

The equipment was designed, installed and maintained by Telefunken engineers. As a result, the police officials in charge of the equipment were not particularly conversant with technical details of the apparatus.

Originally the central equipment consisted of two main transmitters on a frequency of 23.8 Mc/s, and a number of receivers scattered round the city, located in church spires and other high buildings. The transmitters were relatively close to one another, and the reason for using two was not clear, unless one was regarded as a spare in case of bomb damage. Facilities were provided in the Control Room for switching from one receiver to another, the choice being made, it is thought, according to the car being called. Cars were equipped with a receiver and a small transmitter on 27.8 Mc/s.

At present transmission from the cars is not permitted, and the system comprises one main transmitter and a number of cars equipped with receivers.

The main transmitter (Kastor) is situated in the Deutschering building in the centre of the city, and gives an output power of 800 watts on 23.8 Mc/s. It is situated in the basement of the building, and is connected by a concentric cable to an aerial on the roof, approximately 120' above ground level. The transmitter is in a steel cabinet approximately 5' x 3' x 3', and is powered from motor generators external to the cabinet, remotely operated from the Control Room. The mechanical lay-out of the transmitter calls for no particular comment.

A circuit diagram is shown in Fig. 3. It consists of an LC oscillator on 5.95 Mc/s, an amplifier, two doubling stages and a final amplifier. The output stage includes two Telefunken RS 384 valves, working at 2000 v; these are not suitable for frequencies much exceeding 30 Mc/s except at lower anode volts and output power.

Frequency modulation is achieved by a pair of push-pull reactance valves connected directly across the oscillatory circuit. The circuit arrangement calls for comment as it is unconventional and has some advantages.

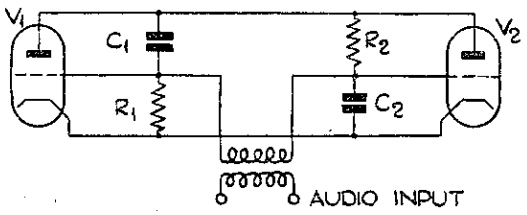


Fig. 4a Conventional push-pull reactance modulator

The conventional push-pull reactance modulator is shown schematically in Fig. 4a, and consists of two valves of which the anode, grid and cathode are interconnected by networks R_1 C_1 and R_2 C_2, the whole being connected in parallel with the main oscillatory circuit. If, at the carrier frequency, the reactance of $C_1 \gg R_1$ and of $C_2 \ll R_2$, neglecting

interelectrode capacities, valve V_1 behaves as a capacitance and V_2 as an inductance. In the absence of modulation, these reactances can be made to cancel at the carrier frequency. When modulation is applied a differential change in valve reactance is obtained, the resistance component being unaltered.

It is usually desirable to carry out modulation at a relatively high frequency, in order to avoid too great a number of frequency multiplying stages. This makes it difficult to achieve the conditions stated above, since the impedance of C_1 and R_2 become comparable with that of the interelectrode capacities. There is no difficulty in the case of V_1, since C_1 can be considered to include the interelectrode capacity, but in the case of V_2 the anode/grid capacity seriously limits the permissible value of R_2 and hence the maximum working frequency, unless special types of circuit are used.

In the case of the Kastor transmitter a different approach is made, which is shown schematically in Fig. 4b.

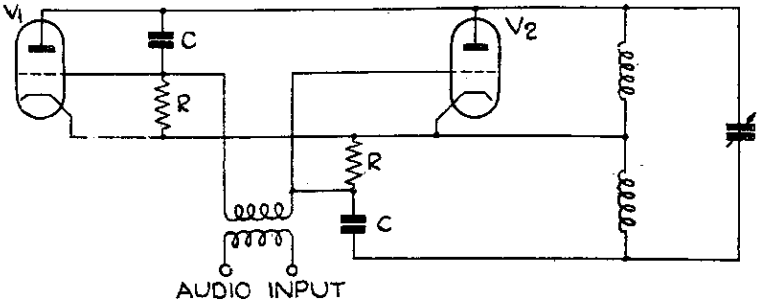


Fig. 4b Kastor push-pull reactance modulator

A push-pull oscillator is used, V_1 being coupled through an RC combination to one end of the tuned circuit, and V_2 to the other end. The phase difference of 180° in the carrier voltages applied to the RC networks produces the same effect as the circuit of Fig. 4a, but without the attendant restrictions. The only difference is that in the circuit of Fig. 4a there is a constant resistance component, which does not change over the modulation cycle; in the case of Fig. 4b the resistance component of V_1 is cancelled by that of V_2, but only in the absence of modulation. Despite this limitation, not usually a serious one, the circuit arrangement is neat, and was previously unknown to the team.

The audio range of the transmitter is 150 - 3500 c/s, and the peak frequency deviation is ± 15 kc/s. No indication of the latter is given, but the audio input level is shown on a meter.

Included in the transmitter is a frequency checking unit. A crystal on 5.95 Mc/s is used in a circuit coupled to the master oscillator, and arranged to give a meter indication when the carrier

frequency is correct. Otherwise no testing equipment is provided with the transmitter.

The car receiver is mounted in a small screened box approximately 12" x 9" x 9", and is connected to a 6' vertical aerial which projects through the roof of the car. The filaments are supplied from an accumulator and the anodes from a vibrator unit.

The circuit diagram, shown in Fig. 5, consists of one HF stage, a mixer-oscillator, three IF stages on 3.03 Mc/s, limiter, Seeley discriminator and an audio output stage; automatic tuning is achieved by using a separate valve controlled by the receiver discriminator. The design, therefore, follows conventional lines; the instrument was compactly constructed but calls for no special comment.

The transmitter originally used in the cars had a nominal output power of 25 watts on 27.8 Mc/s and employed a rotary convertor for the power supply. A circuit diagram is shown in Fig. 6; it consists of an LC oscillator, tripler and final amplifier. In this case the variations in carrier frequency are obtained by a valve, the resistance of which is controlled by the audio input signal. This system of frequency control is not uncommon in mobile communication systems, and is quite satisfactory for small percentage frequency swings. The reason for connecting the 12 volt motor generator supply to the audio input transformer is probably in order to cancel the effect of ripple voltages.

Summarising, the only outstanding point in the equipment is the method of modulation of the main transmitter; otherwise the electrical and mechanical design is sound but conventional. The system as originally planned, with its multiplicity of receivers, seems inefficient and untidy.

Report VI Interrogation of Dr. Kroebel, Guericke GmbH, Kiel, British Zone.

The name Guericke GmbH was a camouflage title for the firm Hagenhuk, operating at Schloss Bredeneck, Preetz, 12 km south-east of Kiel. The Institut fur Elektro-Medizin, which operates in the same building, was associated with Hagenhuk in certain matters. The technical director of the former is Dr. Kroebel, who was interrogated at the Mil. Gov. Building, T. and I. Branch, Kiel, on 24/6/46, by arrangement with Mr. Herford, C.C.G. Officer.

A number of BIOS teams have previously visited Schloss Bredeneck and described the work carried out there during the war. The discussion was, therefore, confined to equipment having specific applications to frequency modulation and television.

The only new information obtained concerned Kroebel's work on rectifiers, and this was rather nebulous. He had experimented with silicon carbide, copper oxide/copper sulphide, and germanium crystals, originally with a view to using them as rectifiers. However, theoretical considerations showed that they must simultaneously exhibit the characteristics of a capacity varying with the applied voltage, and might therefore have application to frequency modulation systems.

The two interdependent phenomena were not completely under control. If, for instance, attempts were made to produce a good rectifier the variable capacity characteristic suffered, and vice versa. Attempts were then made to provide an element which did not rectify at all, but exhibited large capacity variations. It was thought this might have application to frequency modulation on centimetre wavelengths.

Investigation of the high frequency losses in such devices at frequencies of the order of 10,000 Mc/s proved difficult; tests had not reached finality before the end of the war, and were now discontinued.

Kroebel also stated that he had at one time been in touch with a scientist working on a similar problem with a new type of ceramic material. He had no positive information on the results of this investigation, but thought, given time, that he might be able to obtain more details. So far nothing further has materialised, apart from the name of the scientist, which is as follows:

Prof. Falkenhagen,
Dresden, Technische Hochschule.

It is recommended that further enquiries be made about this work.

Summarising, Kroebel's work had little direct connection with frequency modulation and television, and no useful positive information was obtained as a result of the interrogation.

Report VII — Forschungs Anstalt der Deutsche Reichpost, Aach, Nr. Singen, Baden, French Zone.

The Deutsche Reichpost research station at Aach was visited on July 2nd and 3rd, 1946, where the following staff were interrogated:

Dr. Weiss, Director.
Herr Weber, Section Leader.

This station was an evacuation centre for part of the DRP staff, activities being transferred to Aach in October, 1943. The main work carried out concerned television for use in guided missiles, future work being directed towards the development of a high definition

picture employing 1000 lines and a carrier frequency in the decimetre band. The general work carried out has been covered in other BIOS Reports.

The director at the time of the visit was Dr. Weiss, a German television expert. The station is, however, controlled by the French authorities, the officer in charge being Captain Munsch, who was away at the time of the visit. The present activities are restricted to studio work, school and demonstration broadcasting equipment, and repairs to radio receivers.

Weber stated that, in general, tests on television systems and receivers were of a subjective character, and described the type of test made on television receivers immediately before the war as being typical of the testing technique.

Special patterns were projected on to an iconoscope, the pattern consisting of black and white squares; in some squares were sets of vertically and horizontally converging lines, to check the resolution in each direction. Observers at a given distance from a screen were asked to say when the converging lines were no longer separate, and this was compared with the expected resolution for a given number of lines. Good agreement between different observers was obtained. This standard pattern was very similar to the R.C.A. test card in use at the same time.

For checking phase distortion, which introduces 'ghosts', a half black-half white pattern was used.

In order to provide a synthetic 'strip' picture for the pre-war German standard television system (441 lines, interlaced scanning, 50 frames/sec.) an equipment was used whereby the double line frequency of 22,050 c/s was divided in successive stages by 7,7,3 and 3 to obtain the frame frequency. The circuit diagram of this equipment was shown, but it was of a conventional type, and calls for no special comment.

To check the linearity of the receiver, the transmitter was linearly modulated using a portion of the line scanning voltage, and the wave form of a total of two lines only were viewed on a cathode ray tube screen. This gives a picture:

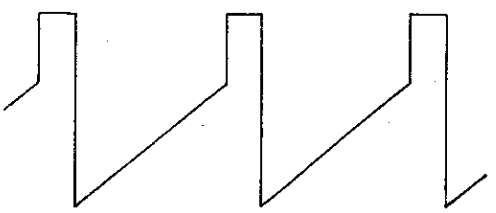


Fig. 7

As the modulation depth was varied the linearity of the 'vision'

signal was viewed on the screen, and 'wander' of the 'black level' observed.

A further test carried out consisted of using linear transmitted vision modulation, and viewing the output from the receiver on a cathode ray tube. The light intensity was measured by means of a small light cell in contact with the tube face. A mask was used to screen the cell from the light other than that which it was required to measure. The overall linearity from the transmitter input to light output could thus be measured.

Weber then went on to describe objective tests made on receivers, but these were of a conventional type. A variable frequency oscillator was used to check the bandwidth, using the DC output of the diode as the indicator; the video amplifier was checked up to a frequency of 3 Mc/s.

Signal generators in which the carrier frequency was varied cyclically and automatically over a range of ±4 Mc/s relative to the carrier frequency of approximately 50 Mc/s have been used, the frequendy response of the receiver being automatically delineated on a cathode ray tube.

A similar instrument, made by FernsehGmbH in 1942, was demonstrated; this was used for testing the frequency response of the intermediate frequency amplifier of television receivers. The generator contains four oscillators, one swept over the range 46 - 54 Mc/s, and others on fixed frequencies of 46, 40 and 34 Mc/s, any one of which could be switched on. The difference frequency is selected, giving outputs of 0 - 8, 6 - 14 or 12 - 20 Mc/s as required.

The variation in frequency was carried out at 25 c/s by varying the current through the inductance of the variable oscillator, which has an iron core.

The output is also passed through a valve in whose anode are circuits tuned to 1, 7, 13, 19 Mc/s; the output is rectified and fed to the indicator circuit, thus placing calibration 'pips' on the cathode ray tube.

The output of the oscillator could be varied over a wide range, but the gain of the cathode ray tube amplifier was fixed, requiring 1 v. input to give full scale deflection on the 9" diameter tube, in which the anode voltage was 5000.

A booklet containing operating instructions and circuit diagram of the instrument was seen, and a request was made for a copy of this document to be prepared. It was stated that the copy would be ready for collection by FIAT at the end of July 1946, but this has not been received, despite repeated requests to M.o.S.

Report VIII Siemens Halske, Munich, Hofmannstrasse 51, American Zone.

This target was visited on July 5th, 1946. Dr. Holzler and a number of German staff were interrogated, all of whom were very co-operative.

The information given in Report I was confirmed, namely that Siemens Halske have developed no test equipment for television, as they had no specific war programme in this branch; further, their activities concerning frequency modulation have been limited to signal generators. Three different types were being developed but none reached finality, nor were any actually produced for distribution. They had, however, all reached the stage of being completed as laboratory models. The work was carried out in Berlin and the equipment had either been destroyed or evacuated by the Russians.

The three types of FM signal generators are distinguished by their frequency ranges, and are described below.

1. Instrument No. Rel. Send 29a, 0.5 - 20 Mc/s.

This instrument was made in Berlin in 1942, one 'bread-board' and one laboratory model having been completed, both of which have since disappeared; the circuit diagram is shown in Fig. 8. The instrument covers a range of 0.5 - 20 Mc/s, and has a peak frequency deviation which can be varied up to $\pm$0.5 Mc/s; it can also be amplitude modulated. The output was fixed and was approximately 1 v. into 70 ohms, the intention being to follow this with a separate attenuator. The complete instrument was in a screened case approximately 30" x 24"x24".

The generator includes an oscillator having a fixed mean frequency of 50 Mc/s, varied over a range of $\pm$0.5 Mc/s by a reactance modulator. A variable oscillator on 50 - 70 Mc/s was combined with the fixed oscillator and the difference frequency, 0.5 - 20 Mc/s, selected; the ratio of the amplitudes of fixed to variable oscillator was approximately 10:1. Two wide-band stages of amplification complete the circuit, the output being taken through a wide-band transformer.

The fixed oscillator was automatically stabilised using a pair of diodes, one tuned to a frequency below, and one above the mean carrier frequency. The variable oscillator was said to be reasonably stable and did not require automatic control; it appears, however, to be stabilised against anode voltage variations by means of a bridge circuit containing a neon lamp.

Amplitude modulation was achieved by passing the modulating

signal through a valve, the output of which was used to control the bias of an amplifier following the fixed oscillator. In the case of FM the LF amplifier and a diode are used in combination to eliminate any amplitude modulation of the fixed oscillator.

The output voltage was read by means of a diode which can be connected across the output stage. Provision is also made in the 'measuring stage' for listening to the AM tone and also for measuring its level. The measuring diode could also be connected through a tuned circuit having a maximum slope at a frequency of 15 Mc/s; by this means variations in frequency were converted to changes in amplitude which were directly indicated on the diode meter. The calibration was carried out statically, and was claimed to be valid over the range 5 - 20 Mc/s - "by careful design".

No technical leaflet describing the signal generator was said to be available.

2. Instrument No. Rel. Send 27a, 5 - 300 Mc/s.

This instrument covers 5 - 300 Mc/s in eight ranges, and was designed to fit into a box 22" x 17" x 11". It was stated that a 'breadboard' model only had been made, but as a printed descriptive leaflet was available it seems probable that development work was nearing completion. The circuit diagram is shown in Fig. 9.

The oscillator could be frequency modulated (using frequencies between 50 c/s and 10 kc/s), the deviation being approximately ±100 kc/s.

A push-pull oscillator was used, the modulation being applied in push-pull to the cathodes, amplitude modulation being thereby eliminated. The frequency deviation was determined statically by varying the cathode potential and thereafter maintaining the input level of the modulation constant. It was claimed that the frequency deviation did not vary appreciably over the range of carrier frequencies, but this is difficult to believe.

To maintain the oscillator voltage constant, a diode across the output circuit was applied to a three stage direct current amplifier, and the cathode voltage of the final valve used as the oscillator anode supply. This may at first seem complicated, but it is probably a very effective way of maintaining constant output over a wide frequency range.

The oscillator was coupled to the following amplifier stage through a capacitive potentiometer giving a variation in output of 10^4:1. In addition a switch on the output circuit could be

used to reduce the output in the ratio 10^2:1, giving a total range of control of 10^8:1. Up to 200 Mc/s the output into 100 ohms was variable between 0.1 μV - 1 mV in one output switch position, and between 10 μV and 100 mV in the other. Between 200 and 300 Mc/s the voltage was approximately one half these values.

The frequency was claimed to be accurate to within 5 parts in 1000, and the output voltage within the following limits:

Frequency, Mc/s.	Accuracy of Output Voltage
5 - 50	± 10%
50 - 100	± 20% ± 0.2 μV
100 - 300	± 50% ± 1 μV

The oscillator could be amplitude modulated by an external source from 0 to 2.3 Mc/s by varying the screen potential of the amplifying stage. Alternatively an internal source of 1000 c/s could be used, the percentage modulation in this case being 30% ±1%.

3. Instrument No. Rel. Send 28a, 350 - 750 Mc/s.

This instrument was an AM/FM signal generator covering the range 350 - 750 Mc/s, and was developed with a view to testing equipments such as FM multi-channel communication systems. A printed descriptive leaflet was available, which indicates that development work was nearing completion. A circuit diagram is shown in Fig. 10.

The oscillator could be frequency modulated to a peak deviation of ±500 kc/s over the range 300 c/s to 400 kc/s.

The push-pull oscillator works on the Lecher wire principle, the frequency variation being obtained by varying the cathode potential of one of the valves. The oscillator anode voltage is stabilised by means of a diode across the oscillator output connected to a two-stage DC amplifier, in a similar manner to type (2) described above. A meter in the diode circuit measures the carrier level. The oscillator frequency is accurate to within ±1%.

The output is variable between 1 μV and 100 mV into a load of 70 ohms.

Amplitude modulation is also possible, the modulation percentage being 50% for an input of 16 v.

The signal generators described above appear to be well designed,

but do not indicate any revolutionary change in technique. The method of modulation and the measurement of frequency deviation are not outstanding. The frequency range covered and the range of output level, however, indicate that great efforts were being made.

It is interesting to note that work on FM signal generators was proceeding simultaneously over such a wide frequency range. This is consistent with other reports that relatively little test gear was available apart from laboratory 'hook-ups'.

The German engineers questioned seemed not to know the precise application in view for the signal generators being designed, apart from the fact that one use in view for type (3) was the testing of FM multi-channel centimetre communication systems.

In view of the large range of frequency, output voltages, and choice of the type of modulation, it seems probable that the instruments formed part of a general development programme rather than tools designed for a specific job.

Report IX P. Gossen, Erlangen, Naagelsbachstrasse, American Zone.

This target was visited on July 8th, 1946, and Herr Kroger, Chief Physicist, interrogated.

The firm makes high grade indicating instruments for direct and alternating currents up to frequencies of the order of 50 Mc/s. No test equipment for FM or television had ever been made or contemplated.

Report X Siemens Halske, Erlangen, Luitpoldstrasse 45 - 49, American Zone.

Dr. Ullrich and Dr. Buchman were interrogated at the above target on July 8th, 1946.

There are two main branches of Siemens at Erlangen - Siemens Reiniger, concerned with electromedical equipment, and Siemens Schuckert, doing heavy current engineering. The German engineers engaged on radio investigations moved to Siemens Reiniger, Erlangen, in October 1945, after the end of the war. They are now working on conventional test equipment for medium wave broadcasting.

Although neither of the persons interrogated had been directly concerned with the subject being investigated, the little information obtained confirmed that given in Report VIII.

3. Targets Considered but not Visited.

No information of any kind could be obtained about the following individuals or firms given in the SIGFSO target list:

R. Abrahamson, Berlin.

J. Junkers, Berlin.

Tonbild Television Society, Berlin.

F. Kurt, Dusseldorf.

The following targets were considered but not investigated for the reasons given:

P. Gossen, Berlin, Gneisenaustrasse 4, American Sector.

This is only a small office in a large block. Two unsuccessful attempts were made to contact the firm's representative, Hoffmann, and it was eventually decided to pursue enquiries at the Erlangen factory. No useful information was, however, obtained there (see Report IX).

Deutsche Philips Berlin, Kurfurstenstrasse 126, British Sector.

This target was reported completely destroyed.

Askania Werke, Berlin, Kaiserallee 88, American Sector.

The only activity of the firm involving radio technique concerned the manufacture of mechanical measuring instruments using electronic methods. It was not considered worth while visiting in the limited time available.

Blaupunktwerke, Berlin, British Sector.

Other BIOS Reports cover the activities of this firm

Fernseh, A.G., Bad Salzuflen, British Zone.

Information obtained from G(T) and C.W., Bad Oeynhausen, was to the effect that this target has been destroyed and the personnel dispersed.

W.C. Heraeus Hanau Main, American Zone.

This probably refers to Heraeus, Vacuumschmelze, A.G., Hanau am Main and Sterbfritz, a subsidiary of Siemens Halske. B.I.O.S. Reports previously published cover the work done by the firm, namely

the making of alloys for special purposes such as sealing into glass. The target was not considered of interest to the team in view of the limited time available in the American Zone.

Josef Neuberger, Munich, Steinstrasse 16, American Zone.

This is a small factory making conventional meters and test sets; the construction is 'cheap' and involves no novel methods of manufacture. This target was not considered worth while visiting.

Te Ka De, Nuremberg, Allersbergstrasse, American Zone.

This is mainly a valve factory and was not considered worth while visiting in the limited time available.

Suddeutsche Apparat Fabrik, Nuremberg, American Zone.

This firm is concerned mainly with the manufacture of selenium rectifiers. the work being described in other BIOS Reports. The target was not considered of sufficient interest to justify a visit in the limited time available.

Forschungs Anstalt der Deutsche Reichpost.

Of the suggested D.R.P. targets at Stadsteinach, Hassenburg Coburg and Aach, it was not possible in the time available to visit all, in view of the long travelling time involved. Aach was considered most worthy of investigation, and the results are described in Report VII.

4. Conclusions.

Investigations by other B.I.O.S. teams have shown that, while test equipment for frequency modulation and television existed, it was not considered to be of any great importance. Further investigation by this team tends to confirm the view that there is little apparatus available of outstanding technical merit, and that so far as could be ascertained, nothing under development which could be considered as anything but conventional. The conclusions reached may be divided into two classes, those relating to (1) frequency modulation, and (2) television, although some items are applicable to both subjects.

Considering firstly apparatus designed specifically for frequency modulation testing, it was found that actual test gear was limited to signal generators. The design of these was sound

but not outstanding, apparatus seen being devoid of anything technically novel or constructionally artistic. The general impression obtained was that it had been decided at some high level that frequency modulation would probably be used over the range 0.5 to 750 Mc/s, and a programme was accordingly laid down. As one part of the programme, engineers had been required to produce signal generators to cover this range, without necessarily having any knowledge of their application or of the need for other associated equipment. This programme appears to have been ambitious as regards frequency range and stability, range of output voltage, and choice of types of modulation. These requirements greatly complicated the design difficulties, and have made the instruments complex by comparison with similar Allied instruments.

The stage of development reached at the time of this investigation could barely be called pre-production, as in many cases the information available was more of the nature of design data than of performance records. In some cases it was expected that the requirements would ultimately be met by "careful design".

The testing of frequency modulated transmitters seems to have been done as a purely laboratory measurement, and no use seems to have been made of deviation meters. Distortion received some attention, but where no apparatus was available for making dynamic tests, conclusions were based on the results of static tests.

Secondly, the apparatus for television receivers was still in the laboratory stage, and in general seems to have been expected to remain so, a useful tool for development work rather than an essential aid to production. This attitude is not difficult to understand as television had no war-time uses other than its somewhat limited application to guided missiles. It is of interest to note that high-definition television had been under consideration by the Deutsche Reich Post (see Report VII).

The use of frequency modulated signals having a low modulation frequency, in conjunction with cathode ray oscilloscopes for providing visual response curves, seems fairly general. Some of the apparatus was in final production form, notably one instrument made by Fernseh, GmbH, which could be applied to television testing and for general FM measurements. The use of pulse modulated signals does not seem to have been adopted to any appreciable extent other than by Lorenz.

The use of variable permeability iron in frequency modulated oscillators is common practice, but little progress seems to have been made in the application of material of controllable specific inductive capacity for producing FM signals.

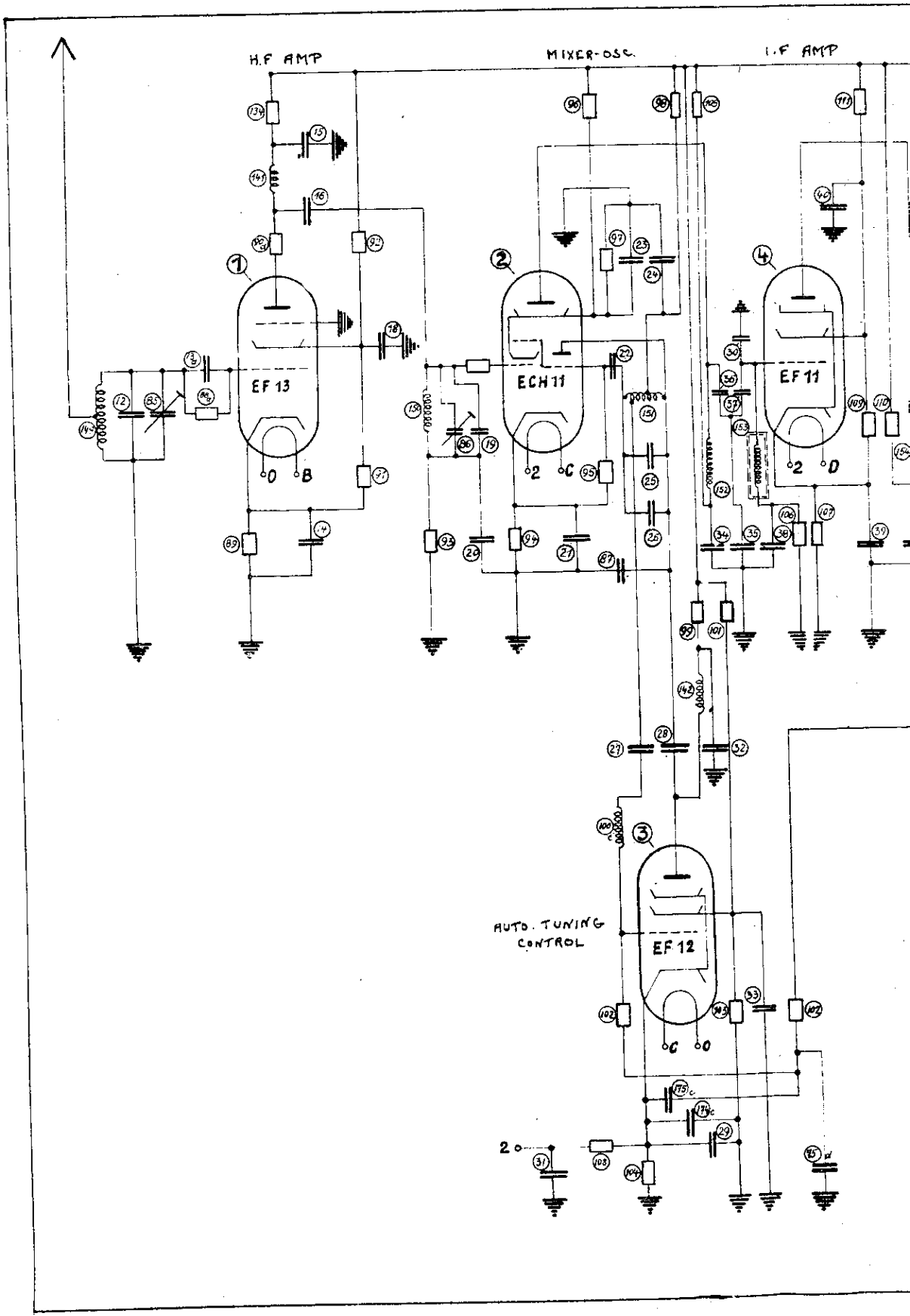
In general, the development of all test gear seems to have been

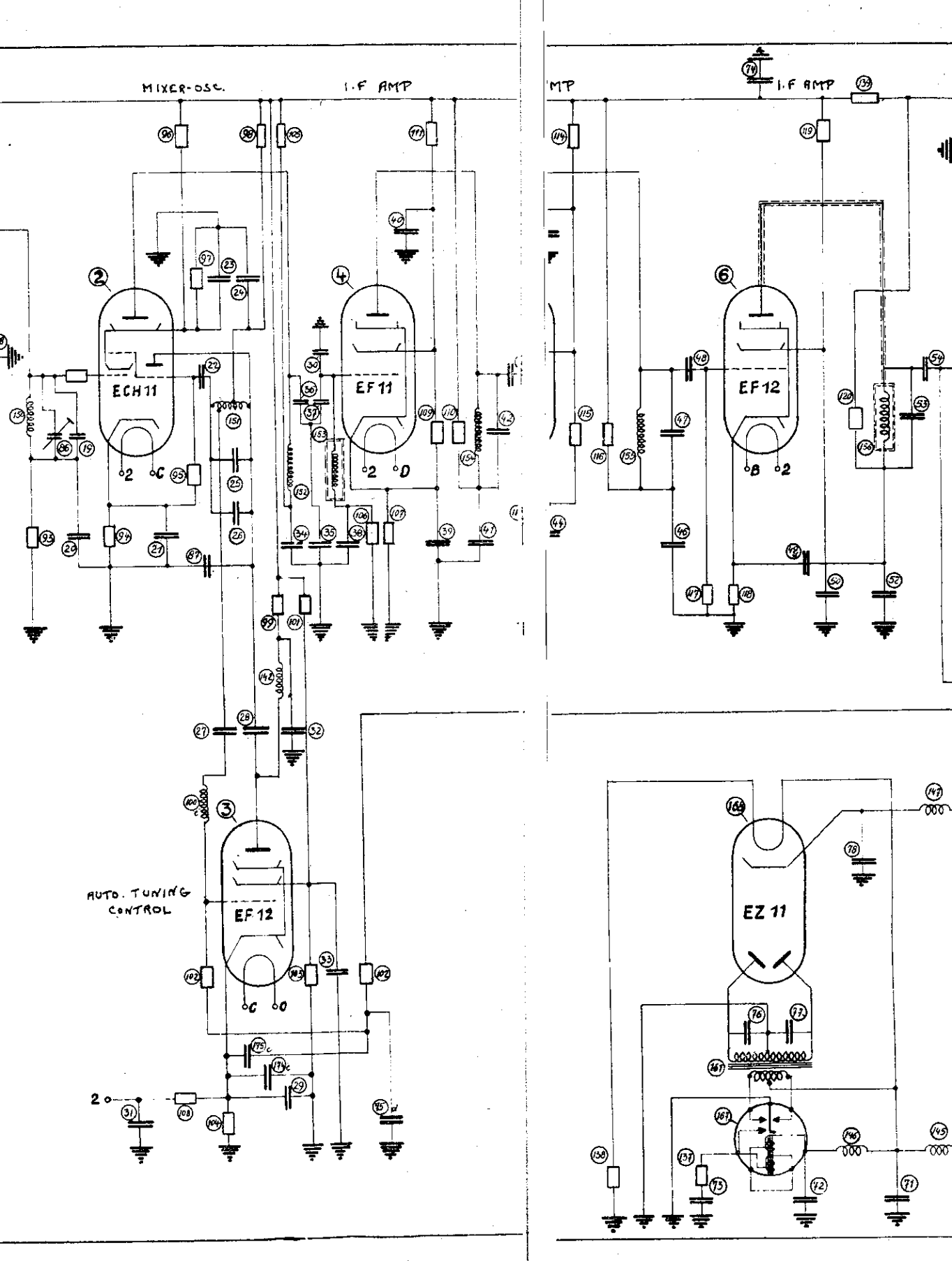
dependent on the demand for apparatus for war-time uses, and projects having no immediate war-potential made little progress after 1938. Difficulties inseparable from the dispersal of research and development groups seem to have resulted in a certain amount of duplication of effort. As a result of these and other limitations, so far as this investigation is concerned, there seems little to show for the past six years work, and the general test gear position is comparable with that existing in Allied countries in 1939.

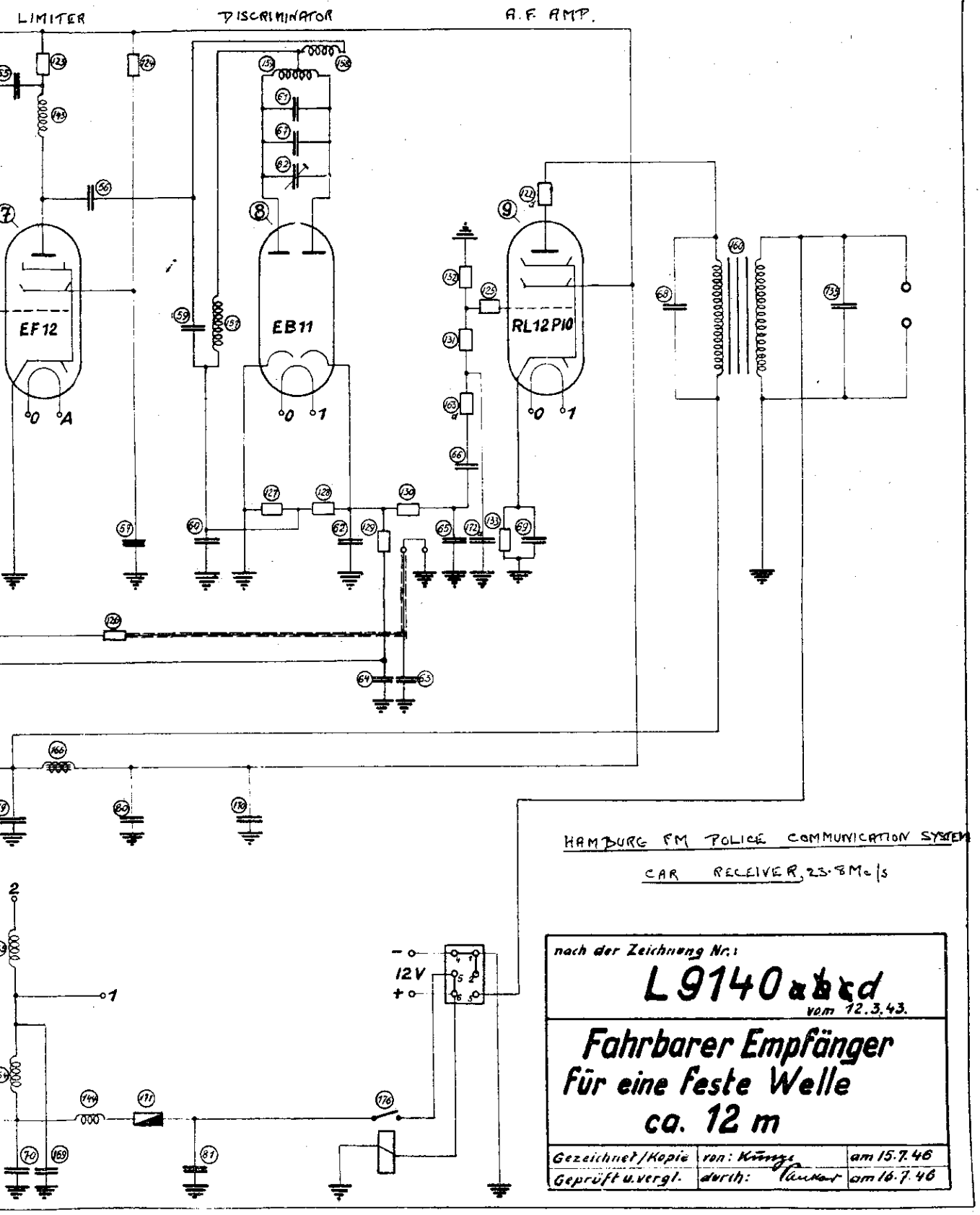
HP/WMB/DC

6/2/47

BZ RPO (HAMBURG)




MIXER-OSC.
I.F AMP
I.F AMP
ECH 11
EF 11
EF 12
EF 12
AUTO. TUNING CONTROL
EZ 11



HAMBURG FM POLICE COMMUNICATION SYSTEM

CAR RECEIVER, 23·8 Mc/s

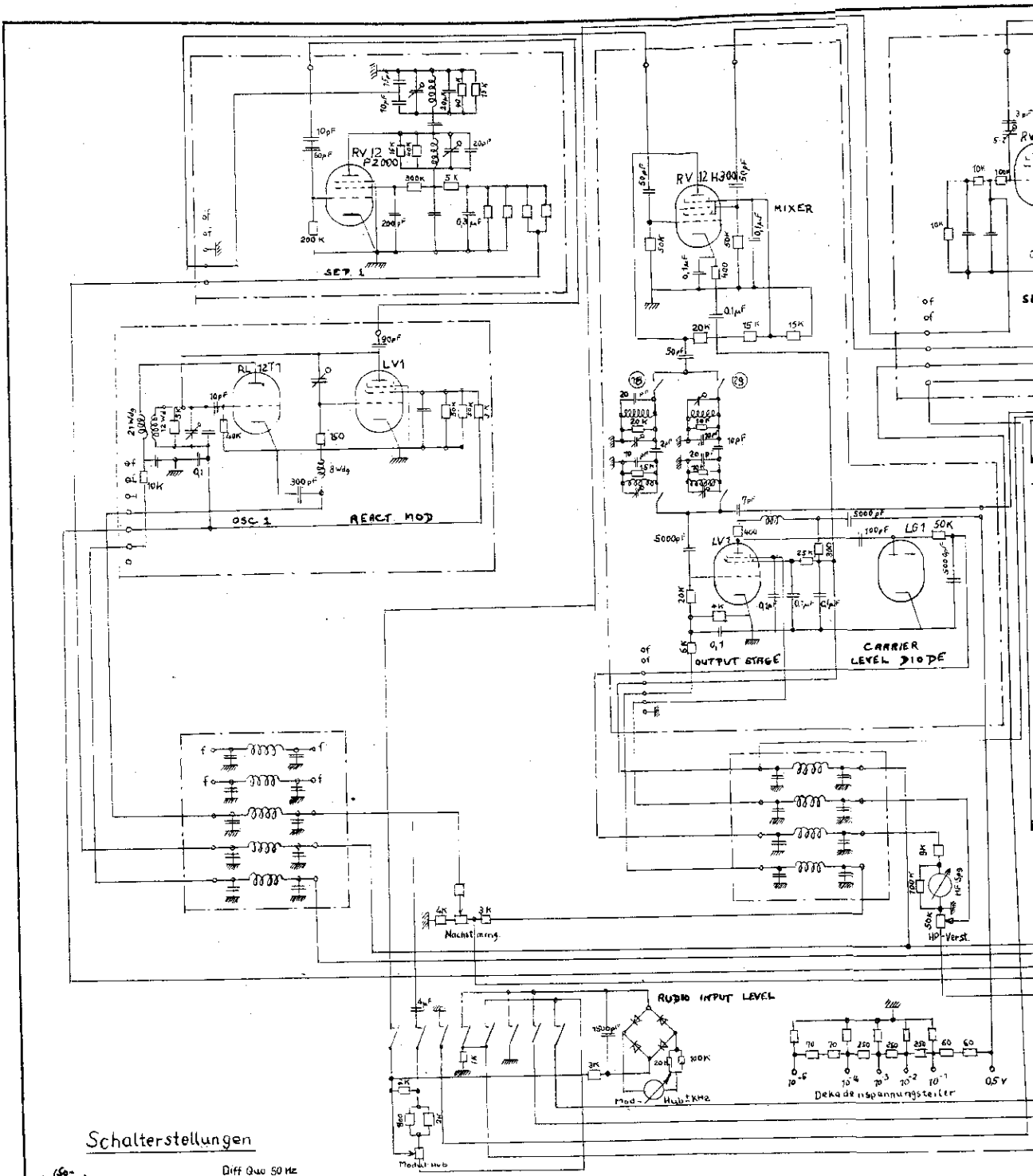
nach der Zeichnung Nr.:

L 9140 a b c d

vom 12.3.43.

Fahrbarer Empfänger für eine feste Welle ca. 12 m

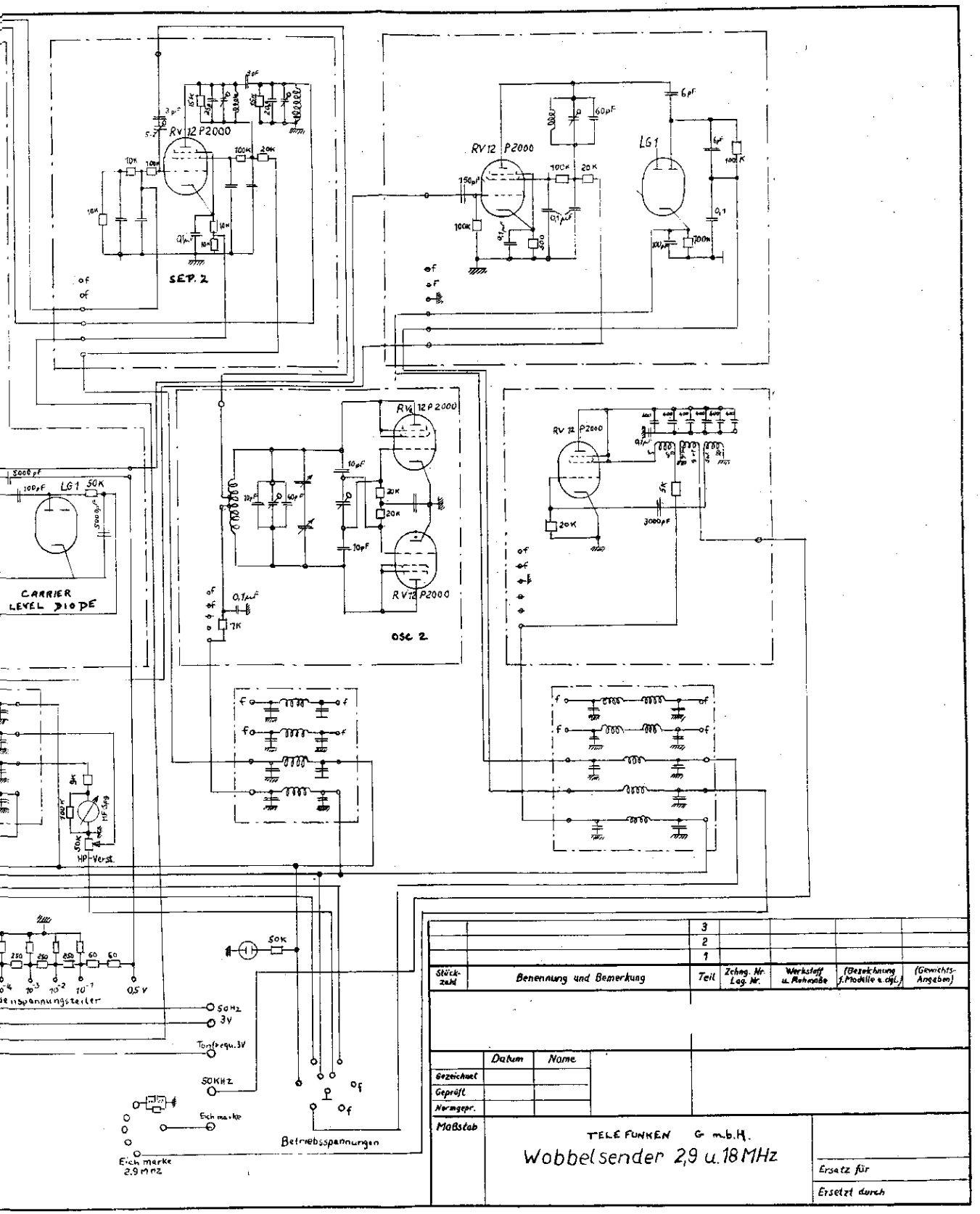
Gezeichnet/Kopie	von: Künzel	am 15.7.46
Geprüft u. vergl.	durch: Lauter	am 16.7.46



Schalterstellungen

1. FM (Sonderbereich)	●	●	●	○	○	●	●	Diff Quo 50 Hz 5 ÷ 10 KHz
2. A.M	●	○	○	○	●	○	○	Amplitudenmod
3. FM (60)	○	●	●	○	○	●	●	50 Hz
4. FM (60 Mod)	○	●	●	○	●	●	○	Frequenzmod Tonfrequ

Eich marke 2,9 m Hz



Stückzahl	Benennung und Bemerkung	Teil	Zchng. Nr. Lag. Nr.	Werkstoff u. Abmessg.	(Bezeichnung f. Modelle u. dgl.)	(Gewichts-Angaben)
		3				
		2				
		1				

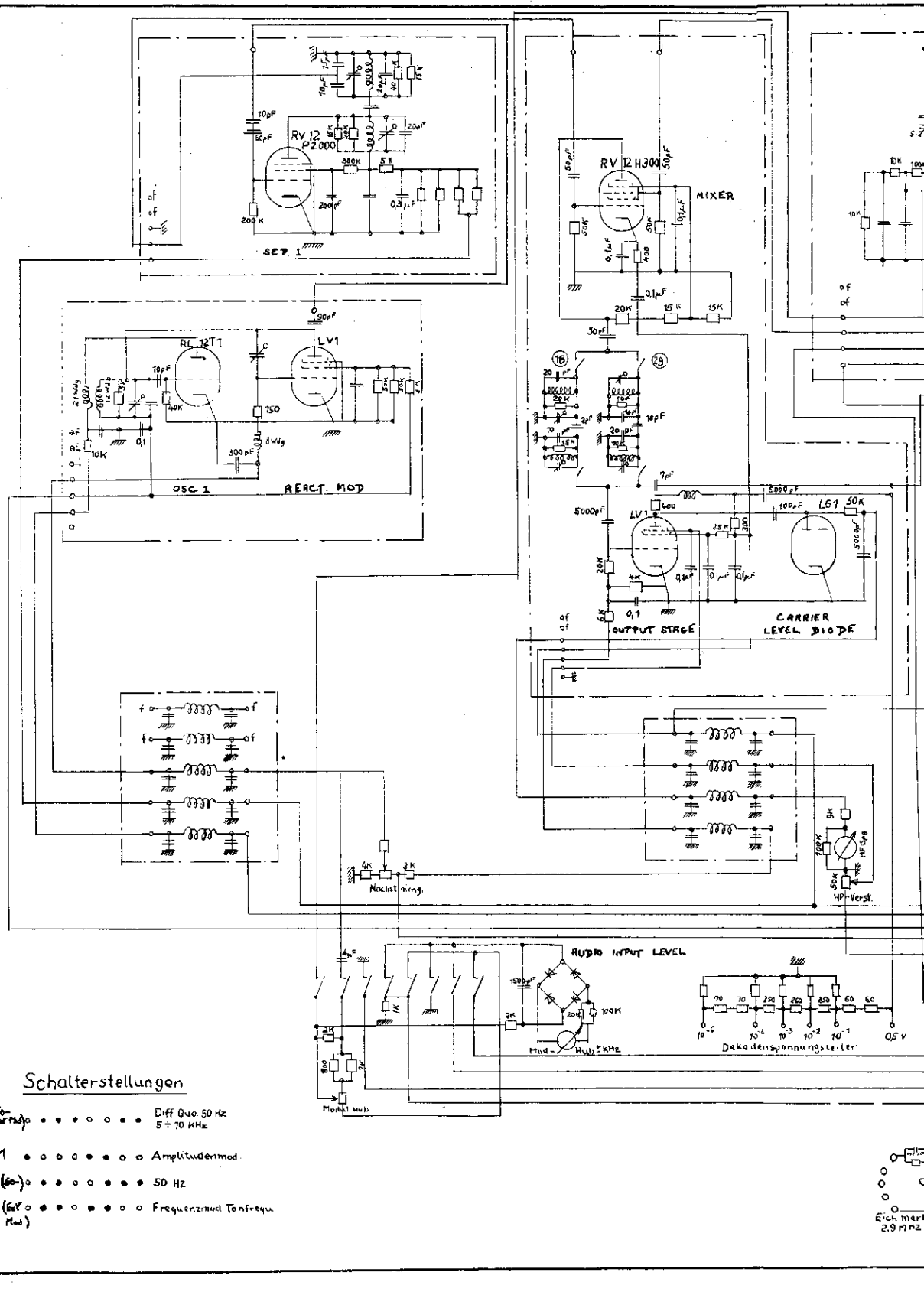
	Datum	Name
Gezeichnet		
Geprüft		
Normgepr.		
Maßstab		

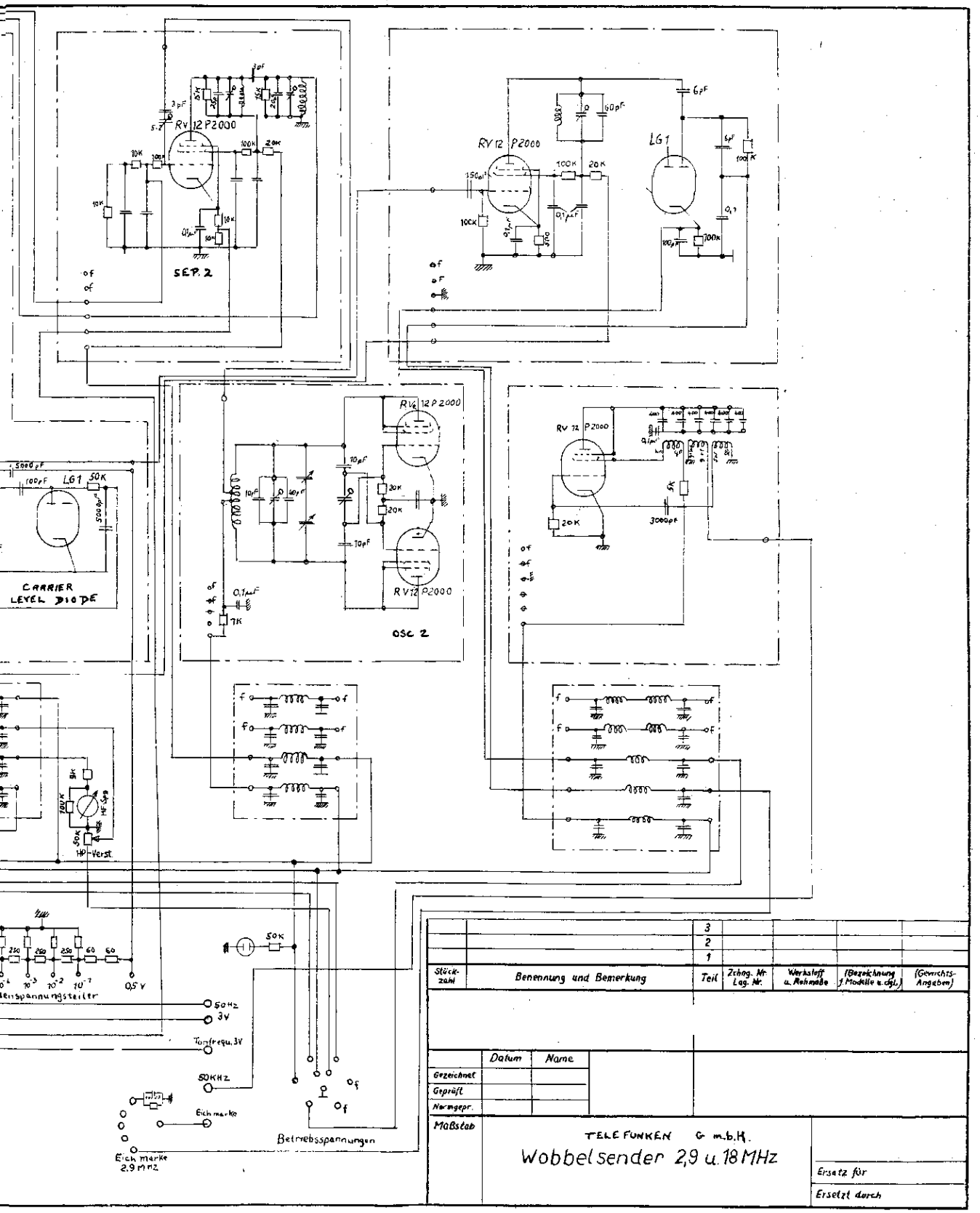
TELEFUNKEN G m.b.H.

Wobbelsender 2,9 u. 18 MHz

Ersatz für

Ersetzt durch


RV 12 P2000
SEP. 1
RV 12 H300
MIXER
RL 12T1
LV1
OSC. 1
REACT. MOD
OUTPUT STAGE
CARRIER LEVEL DIODE
LG1
Nachstr. mng.
HF-Spg.
HF-Verst.
AUDIO INPUT LEVEL
Mod.-Hub 1 kHz
Dekadenspannungsteiler
0,5 V
Schalterstellungen
1. FM (50-fach Mod.) Diff. Quo. 50 Hz 5 ÷ 70 kHz
2. A.M Amplitudenmod.
3. FM (60-) 50 Hz
4. FM (60-fach Mod.) Frequenzmod. Tonfrequ.



		3				
		2				
		1				
Stück-zahl	Benennung und Bemerkung	Teil	Zchng. Nr. Lag. Nr.	Werkstoff u. Rohmaße	(Bezeichnung f. Modelle u. dgl.)	(Gewichts-Angaben)

	Datum	Name
Gezeichnet		
Geprüft		
Normgepr.		

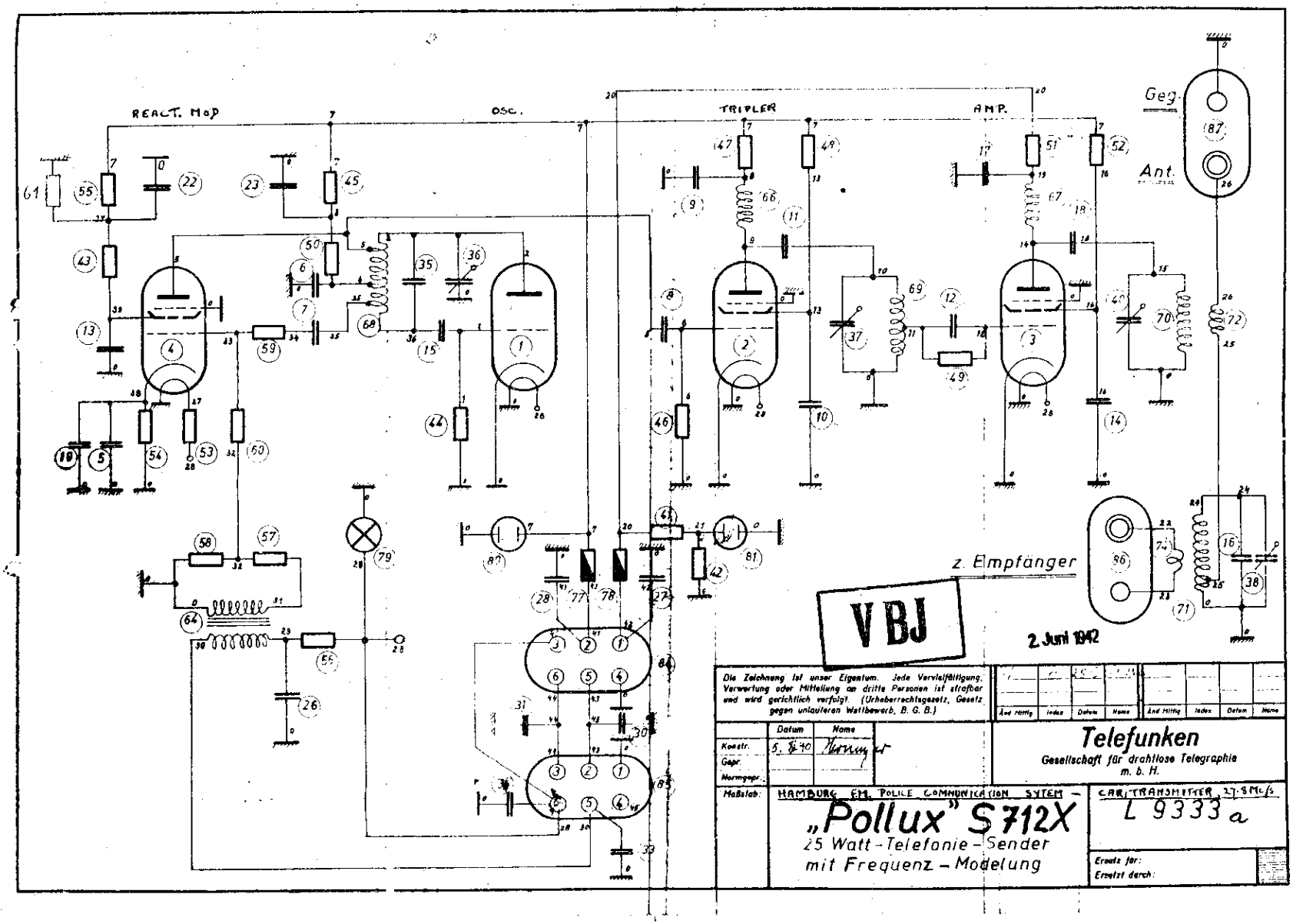
Maßstab

TELEFUNKEN G m.b.H.

Wobbelsender 2,9 u. 18 MHz

Ersatz für

Ersetzt durch



	Datum	Name
Konstr.	5. 7. 40	Hermann
Gepr.		
Normgepr.		

Maßstab:

Telefunken
Gesellschaft für drahtlose Telegraphie m. b. H.

HAMBURG FM. POLICE COMMUNICATION SYTEM –

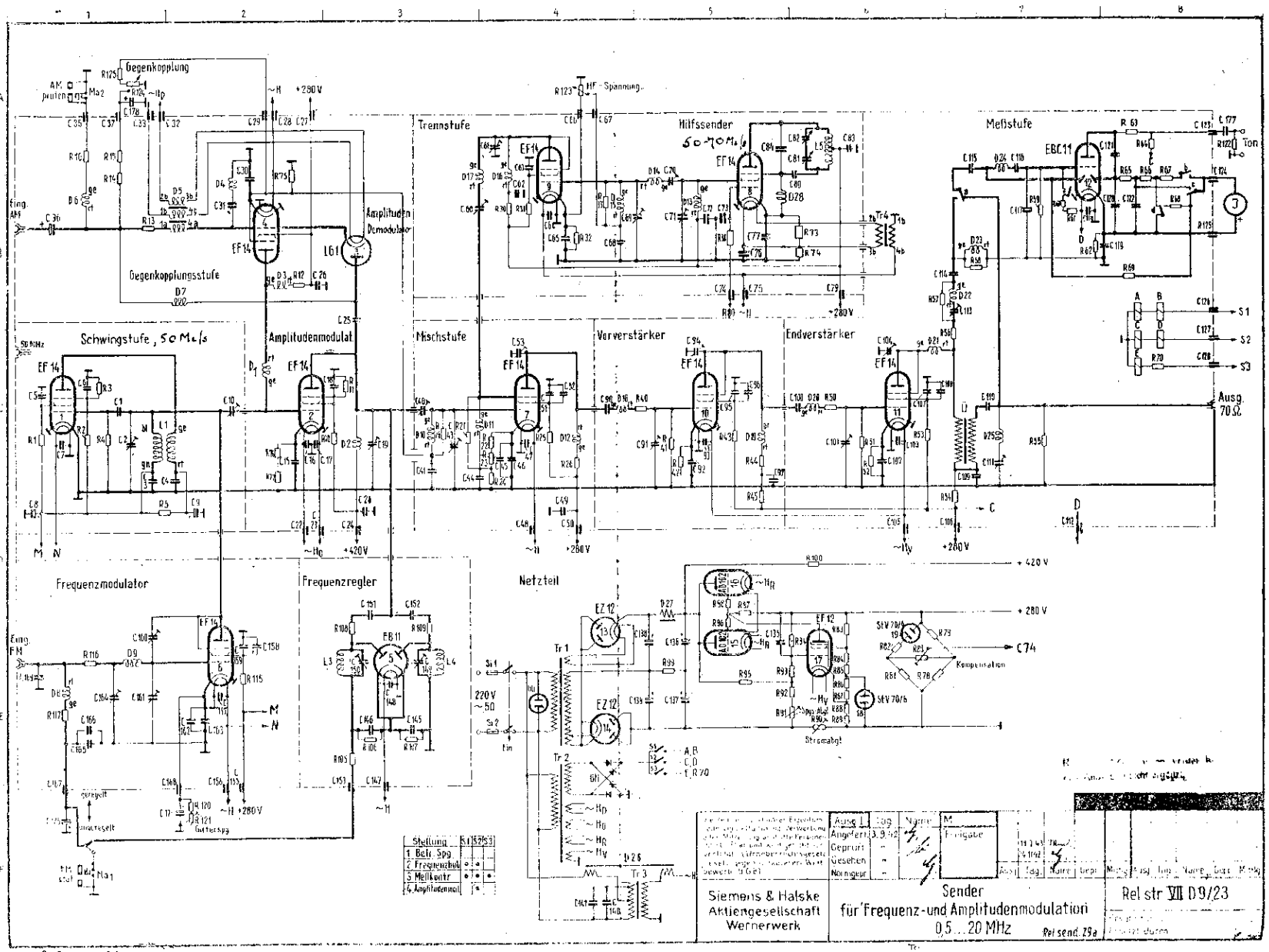
„Pollux" S 712X

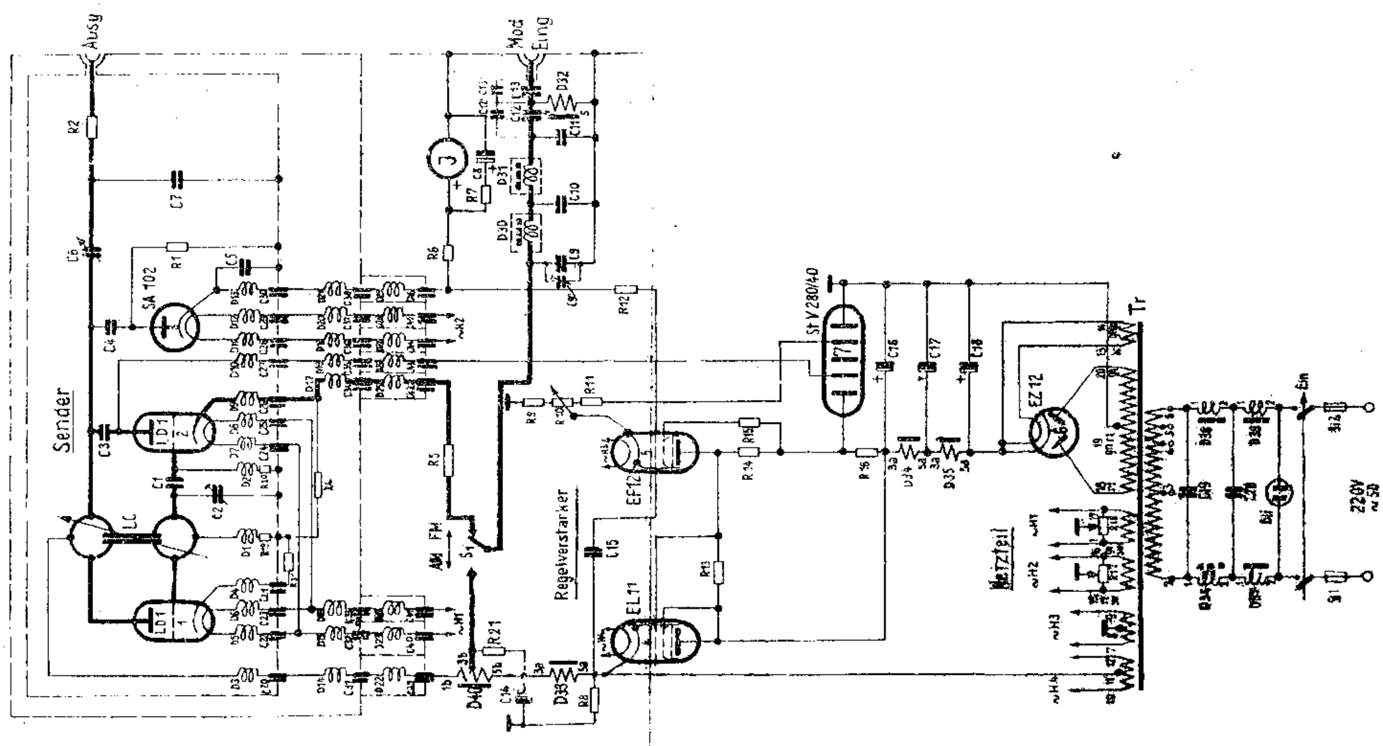
25 Watt-Telefonie-Sender mit Frequenz-Modelung

CAR TRANSMITTER 27.5 Mc/s

L 9333 a

Ersatz für:
Ersetzt durch:


Gegenkopplung
Gegenkopplungsstufe
Amplituden Demodulator
Trennstufe
Hilfssender 50-70 Mc/s
Meßstufe
Schwingstufe, 50 Mc/s
Amplitudenmodulat
Mischstufe
Vorverstärker
Endverstärker
Frequenzmodulator
Frequenzregler
Netzteil
Ausg. 70 Ω
220 V ~50
Kompensation
Stromabgl.
Sender für Frequenz- und Amplitudenmodulation 0,5...20 MHz
Rel sender 29a
Siemens & Halske Aktiengesellschaft Wernerwerk
Rel str VII D9/23



Beachtung: Pausen werden bei evtl. Änderung nicht ergänzt.

Ausg. I	Tag	Name	M
Angefert.	1.10.42		Freigabe
Geprüft	"		
Gesehen	"		
Normgepr.	"		

Ausg.	Tag	Name	Gepr.	Mittlg.	Ausg.	Tag	Name	Gepr.	Mittlg.
–	7.7.44								
–	20.1.45								
–	14.11.45								

Siemens & Halske Aktiengesellschaft Wernerwerk

Prüfsender 375 ··· 750 MHz

Rel send 28a

Rel. str. VII B 9/24

Ersatz für
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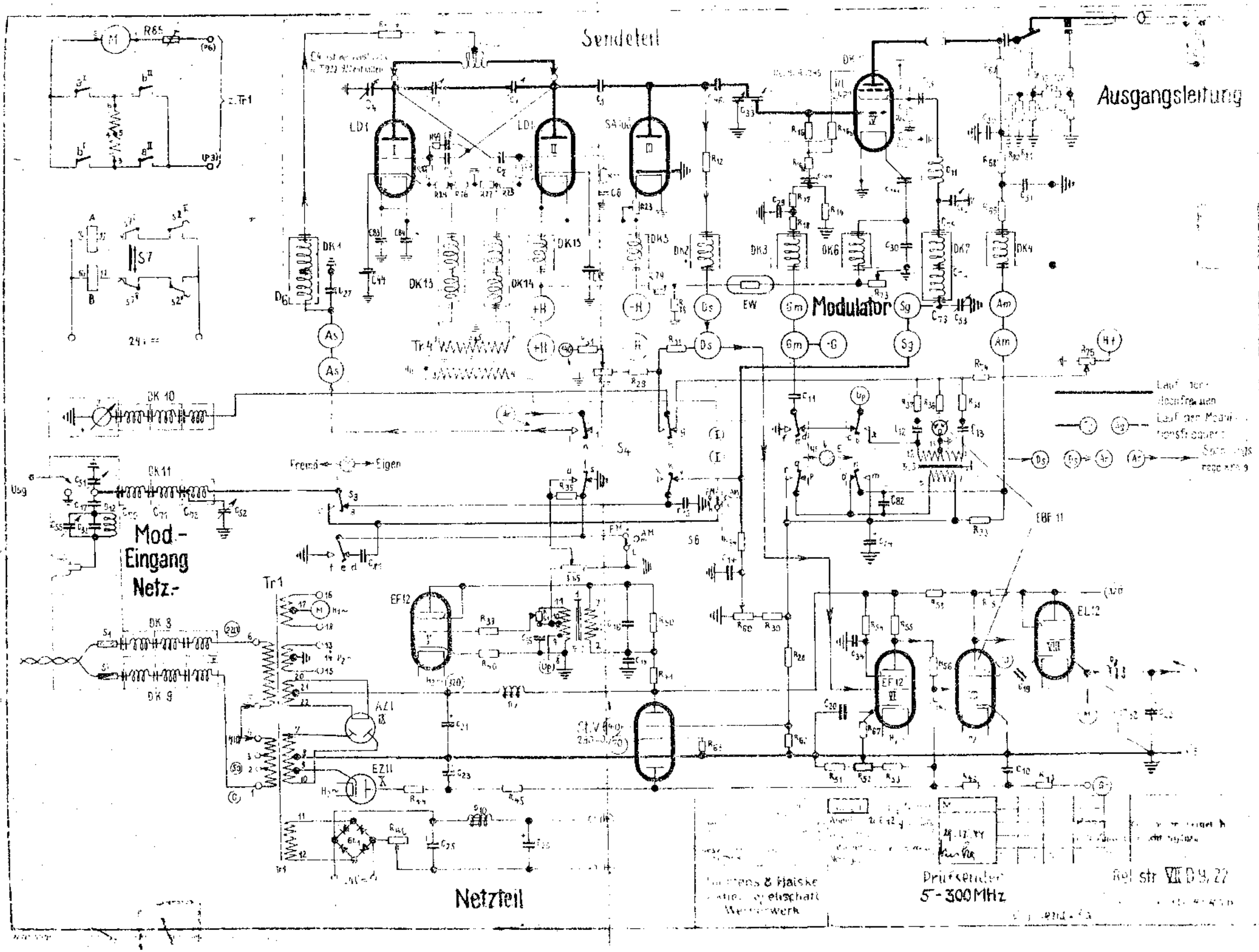

0,5...20 MHz
Rel send. 29a
Sendeteil
Ausgangsleitung
Modulator
Mod.-
Eingang
Netz.-
Netzteil
Fremd
Eigen
EBF 11
EF12
EL12
AZ1
EZ11
Tr1
DK 10
DK 11
DK 8
DK 9
S7
Siemens & Halske
Aktiengesellschaft
Wernerwerk
Prüfsender
5-300 MHz
Rel str VII D 9, 22