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Standardization of electronic components

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SUMMARY

In the first section a survey is given of the reasons which lead to standardization in general and of the advantages to be obtained. In the further sections, the field of electronic components is reviewed. An important international activity is developed by the relevant Technical Committee of the International Electrotechnical Commission (IEC), which standardizes along the line: definitions — measuring and test methods — simplification. Special attention is paid to the classification on the basis of environmental conditions of use. A short summary of the progress up to now is given.

Why standardization

It may be well to consider the general aspects of standardization before starting on the subject of this article, especially for the benefit of those readers who are not in regular contact with this field of technology. The most widespread idea about the object of standardization is, that it is the art of making a restricted choice between a great number of types. This, however, is only part of the truth. To put it in rather general words: the object of standardization is to obtain economic assets for all parties concerned by making a sensible choice from the multiplicity of possibilities. Note the differences between these definitions. First of all, the "economic assets", whatever they may be, and *not* the choice are the object, the latter only being the means. This must be kept well in mind.

Secondly, the first definition speaks of "types" where the second mentions "possibilities". This has the appearance of a pitfall and will be explained with a simple example.

Transmission shafts are functionally characterized by the

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mechanical power they can transmit. So having decided on the material, and leaving aside such details as surface condition and roundness, the obvious thing to do is to lay down a series of diameters and associated tolerances.

The same procedure might be followed for one or two other shaft materials, but it appeared to be possible to cover the greater part of the need by one material, viz. wrought steel for automobile and general engineering purposes. This forms an example of a standardization of types, commonly called *simplification*. The "economic assets" also become clear for this case; the manufacturer will have a bigger turnover in less types and the users will have less types in store, resulting in smaller total stock and smaller investment. These savings can be partly expressed in money.

This, however, is not the end of the story. The user is generally interested to know whether what he buys conforms to specification, in this case the standard. Checking of dimensions does not raise undue difficulties, but checking of material is certainly more complicated. For that purpose, the dimensional standard of the shaft should be backed by a material standard.

But here we have only one "possibility" of checking the delivery. For example, the user may not be interested in the composition of the material he gets but in the strength only. Therefore he may decide to carry out a mechanical test, such as a torque test, instead of checking the material composition. It will be clear that "mechanical test" in itself represents many possibilities.

From this example it will be understood that the task of standardization is not only to make a choice of types, but also to lay down what properties of an article will be tested according to exactly what test method. There is a further very important task, viz. to define accurately what is understood by the different terms applied to a certain article. Here again standardization is a "choice from all possibilities". Going into detail here runs the risk that you will lay aside this article because it's too dull, too theoretical. But we just have to take this risk because the importance of good standard definitions cannot easily be over-emphasized and, furthermore, it will show one of the corner-stones of standardization.

The opinion is often expressed that practice provides a sufficient grasp of the meaning of most if not all terms. Everybody knows what is meant by resistance, inductance or wattage.

This is correct, because these terms are derived from physics and have been defined there. But as soon as you apply these terms to an article, difficulties may arise. For instance, what is the rated wattage of a resistor? Now it must be admitted that, when the complete standard for resistors is available, it may follow from the test methods what is to be understood by rated wattage. However, not everybody is able to find out so readily from the test method what the definition is.

To find a definition is not difficult in this case. It may run something like: the wattage that the resistor is able to dissipate continuously at a given ambient temperature. Consequently, a published figure for rated wattage has no meaning unless the relevant ambient temperature is also given and unless there is some understanding about how long "continuous" is, that is about the life duration.

The above may be called a physical definition. The question arises whether it is adequate from the point of view of standardization. Let us suppose we have to compare two resistors of known rated wattages. First we have to find in the manufacturer's data sheet the temperature corresponding to that wattage. If these temperatures are not the same, we have to find the permissible wattage at one temperature from the so-called derating curves, i.e. the curves showing the percentage of rated wattage as a function of the ambient temperature.

The advantage of such a physical definition is obviously that it induces manufacturers to publish the wattage rating together with the appropriate temperature, and so eleminates misunderstanding. However, the comparison of resistors of different make may still be a tricky business and confusion is liable to arise. It would be a great advantage if it were possible to obtain agreement on one temperature to be used by all manufacturers and users, say 40 °C. The definition would then include all factors necessary for direct comparison and such a definition can be called a standard definition.

It will be noticed that the agreement on life duration has been left out. This is a very difficult subject, to which standardization cannot give a simple solution. Of course it is possible to add the words "for five years" to "continuous" in the definition, but this would not have much technical meaning. Firstly sufficient data over long time performance are only obtained at high cost and much trouble, and secondly, it would imply a long-term guarantee. The only practical possibility is to prescribe in the standard an endurance test of adequate length, say 1000 hours, under severe operating conditions, and to specify the maximum permissible deterioration after that test.

So even standard definitions may not be strictly complete but for practical every-day life they are satisfactory and indispensable.

This shows an important aspect of the matter. Definitions including the measuring and test methods enable us to define the properties of an article completely. If done in the proper way, different makes of articles are directly comparable and there can be no misunderstanding between manufacturer and purchaser or any other confusion. To put it in another way: "all parties speak the same language". Here we have another aspect of the economic assets mentioned in the beginning, perhaps the most important one. To derive full advantage from a standard in this respect, a first condition is that it should be generally accepted and used. Again, standardization is not the aim but only the means to come to a better understanding.

A standard may be completely sound technically, but when for some reason or other it is not acceptable to some interested party, it is liable to increase confusion instead of decreasing it. The best standard is the one on which general agreement can be reached, even when it is either incomplete or even not fully in accordance with the state of technical development.

It will be noted that in the above three distinct phases have been introduced. This has, however, been done in the wrong order. When work on a new subject is started, it is common practice to begin with definitions. As soon as sufficient idea has been formed by the committee as to the concepts they are talking about, so that during the *discussions* there can be no misunderstanding, it may be good to leave the definitions aside for a while and to focus attention on the test and measurement methods. These can be regarded as a supplement to the definitions and in some cases it is easier to finalize the definitions after the measuring and test methods have been discussed. Finally, the simplification can be taken in hand, comprising the laying down of levels of minimum quality, of restricted series for nominal values and of dimensions. This last activity must be carried out with great caution in order not to lay down rules which might interfere with future development.

Apart from this, there are often one or two subjects such as colour codes and general series of preferred values, which are not quite covered by these three activities, but which are very suitable for standardization.

Of course the relative importance of the three activities varies from case to case. In general, the more complicated a subject is, the more important the first two activities are. Electronic components *are* complicated.

To sum up the "why" of standardization: the aim is to promote better understanding, especially between manufacturer and user, to obtain cheaper products of good quality and smaller stocks and similar advantages by creating a well-defined "technical language" and by restricting the number of types. A very important factor is the use that is made of a standard.

Who standardizes

This may seem a rather silly question, but it is of special importance with regard to the application of standards. Best known is the national and international standardization carried out by national standardization authorities such as AFNOR (France), BSI (United Kingdom), HCNN and NEC (Netherlands), and by international bodies such as ISO (International Organisation for Standardization) and IEC (International Electrotechnical Commission). This might be called "general standardization", because *all* interested parties are represented in these bodies (manufacturers, users, education, government etc.). There is, however, much activity in groups of interested parties also. Therefore, standards can be roughly divided into general standards, users' standards and manufacturers' standards.

To start at the bottom: a manufacturer may want to standardize the raw materials he uses. In principle he can do so without consulting anybody, but if he is wise he will ask the advice of his suppliers. He is making users' standards of a rather limited application, but the standards will normally have an obligatory character in his factory and for his suppliers.

On the other hand he may want to standardize his products. Now he makes manufacturers' standards, which may have an obligatory character for his factory but generally he will not have much chance to enforce these on his purchasers.

The manufacturers of similar articles in one country may come together to follow the same procedure. In that case national users' or manufacturers' specifications arise, which as such do not have an obligatory character.

However, when a users' standard is accepted by a sufficient number of manufacturers, it automatically becomes an obligatory standard for the supplier. National manufacturers' standards are only recommendations, but the value of these should not be under-estimated, because in many cases they form the first step to general standardization.

Finally, the same procedure can be repeated on an international basis.

Users' specifications are not only made by industry, but also by other groups of users, such as government departments, administrations, military authorities (service specifications) and broadcasting companies. Since the "groups" of such users within one country are relatively small, agreement within the group is as a rule easily obtained and therefore these standards automatically become obligatory for the suppliers, whereas internationally drafted specifications of such groups are recommendations to the national groups.

All these standards can be turned into general standards by submitting them to the appropriate general standardizing body (national or international) and discussing them with all interested parties. General standards as such are recommendations but can become obligatory when accepted by factories, companies etc. or when referred to in a contract.

Now let us return for a minute to the application of standards. Since the usefulness of a standard is equivalent to its application, the logical consequence for a factory making standards for its own use is to make them obligatory to the greatest possible extent. With respect to national and international standards it can be said that the ideal situation is when all manufacturers and users abandon their own standards in favour of the national or international ones.

A simple way of promoting the application of standards would be to enforce them by law. In a democratic society this would obviously be the wrong way, since only the interested parties are able to judge whether the standard is acceptable to them. An exception should be made for standards involving the safety of persons or property, but even then enforcement by law should be avoided where possible because of the slow procedure of government machinery. Standards have to be kept in pace with technical development and therefore revision is necessary from time to time.

How electronic components are standardized

Up to World War II there had not been much activity in the standardization of electronic components. As a result, similar components of different manufacturers were not electrically and mechanically interchangeable. This created enormous difficulties for the Armed Forces, who therefore started to draw up users' specifications.

After the war, when the manufacture of military electronic equipment was sharply reduced and was replaced by civil production, an attempt was made to use the service specifications for industrial purposes.

This was not a complete success. In the first place, the military qualities laid down in the service specifications were not always suitable for industrial use, and, in the second place, what industry needed were international specifications. Strange as it may seem, the service standards existing at the end of World War II were strictly national.

For this reason in some countries specifications were drawn up covering industrial and entertainment components. In the United Kingdom, these specifications are made by the Radio Industry Council (R.I.C.) which is an organisation of both electronic equipment manufacturers and component manufacturers. Consequently, these specifications are of a rather general character. In the U.S.A., component specifications are made by the Radio, Electronic and TV Manufacturers' Association (R.E.T.M.A.). The RETMA specifications are manufacturers' specifications, which is possible because the component manufacturers are members of RETMA.

Soon after these activities were started, the subject was also taken up on a general international basis, viz. by the International Electrotechnical Commission (I.E.C.).

The constitution of IEC, which last year held its 50th anniversary meeting, is as follows. The members of IEC are what are called the National Committees, i.e. the national general electrotechnical standard organisations in the member countries, or special national committees formed for that purpose. At the moment there are about thirty-five members.

At the top of IEC is the Council, consisting of president, vice-presidents (all presidents of the National Committees), treasurer and general secretary. The president is elected every three years. At the moment it is Dr P. Dunsheath (United Kingdom).

The next body is the Committee of Action, consisting of the president, 9 vice-presidents, treasurer and general secretary.

They take the final decisions on most technical questions. The technical work proper is done by the Technical Committees and their Sub-Committees. There are now over 40 Technical Committees, more than 10 of which have been installed since the last war. Each Technical Committee has a chairman and the secretariat is entrusted to a National Committee, normally not the one to which the chairman belongs. The Secretariat prepares the documents to be discussed in the meetings, makes the minutes etc. Distribution of documents and all other administrative functions are taken care of by the General Secretariat, the Central Office, residing in Geneva.

Before World War II, most of the Technical Committees either dealt with general technical subjects, such as nomenclature and symbols, or with power equipment, such as alternators, insulators and switch gear. Only one Committee was active in the telecommunication field, viz. TC 12 "Radio Communications" which discussed at that time safety requirements for broadcast receivers. The Secretariat was — and still is — in the hands of the Netherlands.

When the need was felt to do more work in the electronic field, it was only logical to extend the scope of TC 12. In 1948 it was decided accordingly and four Sub-committees of TC 12 were installed to handle the new subjects, viz.

1. measurement methods for receivers,
2. safety,
3. components and
4. electronic tubes and valves.

At a later date, Sub-committees for high-frequency cables, for piëzoelectric crystals and for transmitters were added to the list, the latter only quite recently.

On the other hand, the subsequent re-organisation caused a reduction of the number of Sub-committees of TC 12. Soon it appeared that the Sub-committee for electronic tubes and valves could not restrict itself to radio communication, since tubes find general application in the electronic field. Therefore it was decided some years ago to convert the relative Sub-committee into an independent Technical Committee (No. 39). The same procedure was followed last year with respect to the Sub-committee for components, which is now TC 40, absorbing the Sub-committees for high-frequency cables and for crystals.

What is standardized in I.E.C. for electronic components

When a component is bought it is expected to give a certain performance for a certain time. It is hoped that the performance will be as good as possible and the life indefinite, but if at the same time the component should be obtainable at reasonable cost, it is clear that a compromise has to be made somewhere.

Now the concept of performance has many aspects. In the first place the component is expected to have a certain property of a given value, let us say a resistance of 100 ohms which will stay constant over a sufficiently long period. Since nothing is absolute, it must be accepted that the resistance is not exactly 100 ohms but lies between two tolerance limits, and that it varies somewhat with the circumstances and with time. The latter may be called instability.

In the second place the component will be subjected to a certain load, either continuous or cyclic or intermittent e.g. 1 watt in the case of the above resistor. It is expected that the instability is still acceptable.

In the third place the components are subjected to mechanical and climatic stresses, by mounting them into an apparatus, transporting the apparatus, heating during operation of the apparatus and moist air during no-load periods. Still it is expected that the component will not break down and that the instability will stay within reasonable limits.

All these factors together govern the performance of the component, and its life duration is obviously the time for which the instability during use remains within pre-determined limits. The problem is to look for some means to estimate the instability over a certain period of use.

The first step on this way — ascertaining the properties of the component — does not raise undue difficulties. There are scores of measuring bridges, dynamometers, resistor standards etc. which will give exact information about the component as it has been received. The only thing to be done is to specify the measuring methods in such a way that the same result is always and everywhere obtained when the same component is measured. Such details include ambient temperature, load during measurement, inaccuracy of the method, position of the component etc. without necessarily prescribing the instrument to be used. For instance, the resistance of a carbon fixed resistor may be measured by a Wheatstone bridge or by measuring voltage and current, as long as the ambient temperature is between 15 and 25 °C, the voltage at the resistor terminals does not exceed say 25 V and the total inaccuracy of the method used (including the influence of connecting wires) does not exceed 0.5 %.

The next step is to verify that the components will survive the handling previous to and during mounting. One way would be to put a sample of components into a setmakers factory and to see whether the resulting apparatus are all right, but though highly practical this would not be a reproducible test method. For this purpose the component specifications contain a number of mechanical tests, checking the strength of terminals, of mounting accessories and, where necessary. the suitability of being soldered into the wiring. The bumping and vibration tests also belong partly to this group of tests.

After these tests, the components must not have been damaged and the main properties should have changed to a negligible extent only.

The third step is to verify whether the component is suitable for the climatic conditions liable to be met during normal use. Again one method would be to mount the components into an apparatus and to await complaints over a number of years. It must be stated that in many cases this is the only way to obtain exact figures on the behaviour of components during normal use, both for the third and the fourth step. However, experience from both manufacturers and users has made it possible to devise tests of reasonable duration which allow to make reliable predictions about the behaviour under practical circumstances.

The climatic tests comprise: dry heat, dry cold, humid atmosphere, change of temperature and low air pressure, and the special tests: mould growth, corrosive atmosphere and dust. Because these short-lasting tests are to be a measure of what the component is going to do in its life, they are more an exaggeration than a simulation of practical circumstances.

Another thing that is of importance here is the sequence of tests. There would be some logic in carrying out every test on a separate lot of components when each test represents the whole life of the components in a certain respect. On the other hand, components are subjected to all conditions of use simultaneously. For that reason the component specifications generally prescribe the following test cycle to be carried out on the same components, the total cycle representing normal life:

initial measurements (step one)
strength of terminations
soldering
change of temperature
vibration and bumping
dry heat
humid atmosphere (first accelerated cycle)
dry cold
low air pressure
humid atmosphere (further accelerated cycles)

After this cycle, the change of the properties with respect to the initial measurements should be within certain limits. In many cases essential information is obtained by measurements of the insulation resistance. The total cycle takes about 14 days. Apart from this a "long-term humidity test" is carried out which may take up to 84 days.

In the fourth and last step it is tried to obtain information about the resistance to electrical and mechanical loads. In some cases this can be fairly exactly established. For instance, when it is known that a switch is operated twice a day on the average, then it is certain that 10 years life duration is represented by 7500 switching operations. However, in most cases the solution does not present itself so clearly.

Often the life test is based upon rated load under extreme conditions of use (e.g. maximum ambient temperature). It is obvious that such tests must be carried out for a long time to yield accurate results, but for some groups of components it is known from experience that the change of their properties approaches a limit in say the first 1000 hours, and that failure on the average occurs after a multiple of that period. A test of 1000 hours then shows whether the instability is acceptable and, if the number of failures during the test is very small, that the average life is sufficient.

Especially in the case of capacitors it is tried to accelerate the life test by increasing the load, c.q. the voltage. It must be stated, however, that except for D.C. paper capacitors, very little is known about the correlation between normal life and test life.

The problem of life duration is extremely complex and of utmost importance since it is closely related to reliability. What is known about it at present is not yet sufficient for standardization and therefore this matter is not any further discussed here. In IEC specifications about components very little direct reference to it can be found.

What I.E.C. has published for components

Although not explicitly mentioned in the foregoing section it is easy to understand that the work is carried out along the line: definitions — test methods — simplification. For electronic components, definitions, measuring methods and test methods go together fairly well, but it is a rather large step to simplification. Taking into account the difficulty of obtaining international agreement and the relatively short time the Committee has been active, it will be understood that only one specification covering part of this field has been published. In international standardization, time is measured in units of five years.

Apart from this, it was possible to reach agreement on some special subjects which were laid down in the following I.E.C. Publications:

No. 62: Colour code for fixed resistors

No. 63: Series of preferred values and their associated tolerances for resistors and capacitors.

The first publication is a compromise between the most important colour codes for resistors that already existed. It is expected that it will be in general use in the near future.

The second one gives three geometrical series, based upon the same principles as the series of preferred values or Renard series (R-series). The E-series however have 6, 12 or 24 terms per decade instead of 5, 10 or 20. Though generally regretted, it proved to be necessary to standardize these exceptional series for electronic components because they correspond very closely to the values used in practice. The reason for this is the fact that the term ratio of the E24-series is 1.10, so that in the case of a 5 % tolerance there are no gaps between the tolerance ranges of two subsequent rated values. This feature may sometimes be of importance in mass production.

The most important publication, which has been mentioned at the beginning of this section, is No. 68: Basic Climatic and Mechanical robustness Testing procedure for components (BCMT). When work was started on component specifications it was found that the electrical measuring and test methods had to differ from one group of components to the other, but that this is not the case for the climatic and most of the mechanical tests, because the components are used side by side in the same equipment and consequently are subjected to the same conditions of use. Therefore, all the tests indicated under "step three" of the foregoing section and part of the tests of "step two" could be laid down in a general specification.

This, however, does not mean that all components are subjected to exactly the same tests. That would not be logical, since there are internally hot apparatus and relatively cool apparatus, arctic climates and tropical climates, equipment for entertainment and equipment for strictly professional purposes, etc. For that reason, each test of the BCMT is specified in two or more grades of severity, the most severe grade being numbered 4 and the less severe grades 5, 6 etc.

The component specifications indicate to what grade of severity a certain type of component shall be subjected.

It would be possible to put all these figures indicating the test severities in a row, starting with the first test and ending with the last, always in the same order. Then a number of some ten digits is obtained telling how the component has been tested and also what climatic and mechanical conditions it is supposed to withstand in use. Such numbers are not very practical and they give rise to some 10000 possible types or „groups", as I.E.C. calls them.

When the first component specification was drafted — which covered paper capacitors for D.C. — an attempt was made to solve the problem by making a limited choice of four groups. Apart from the fact that this over-simplified the matter, it was found when tackling the next specification that the limited choice there did not at all correspond to the first one. So in fact, when thinking of all components there were still 10000 possible groups which did not match the idea of side-by-side operation in the same equipment.

It was then proposed to approach the matter from the equipment side and the following very simple equipment classification was given:

1. Equipment for high-altitude aircraft
   Equipment for normal-altitude aircraft and heavy-duty ground use
   Equipment for industrial use
   Domestic equipment (entertainment)
2. Equipment for tropical climates
   Equipment for temperate climates
   Sealed equipment

3. Maximum internal temperature of the equipment 55, 70, 85 or 100° C

This made it possible to reduce the above number to a three-digit number, leaving some 50 possible groups, some of which can be deleted because they are unrealistic.

The three-digit number is composed as follows. The first digit corresponds to the severity of the dry-cold test and at the same time defines the severities of the following associated tests: bumping, vibration, rapid change of temperature and low air pressure. All this corresponds to item 1 of the above classification.

The second digit corresponds to the severity of the dry heat test and thus covers item 3 of the classification. There are no associated tests.

The third digit indicates the grade of severity of the humidity test and is associated with the mould growth and salt mist test. It corresponds to item 2 of the classification. According to I.E.C. Publication 68, severity grade 4 of the humidity test is a test with a duration of 84 days which is especially suitable for hermetically sealed components. Severity grade 5 has a duration of 28 days; such components are suitable for most tropical applications.

Components for use in entertainment appliances in temperate climates need only meet the tests of severity grade 6, lasting 7 days.

There is still a fourth type of component, i.e. for use in sealed equipment. According to I.E.C. these are tested as components for domestic use, but such components need not have any moisture protection on the condition that, after drying, their properties are closely equal to the original properties. It is therefore possible that a further severity grade will be added in the near future.

It has already been pointed out that the highest severity grade of every test is indicated by 4, the next lower one by 5 etc. Thus the highest sturdiness group is designated by 444, indicating a component suitable for temperatures from −55° C to +100° C and under conditions of the greatest humidity.

A complete survey of the group number system is given in the table below. The advantage of this system is that it can be understood by component users without a detailed knowledge of component testing. Broadly speaking the first two digits define the extreme temperatures between which the component may be operated, taking into account the appropriate derating. Apart from this, the first digit indicates the intended use (first part of the classification). The third digit defines the humidity protection.

It remains to be seen whether the system is sufficiently flexible to be suitable for the majority of components, especially with regard to the association of the mechanical tests to the minimum temperature rating. It is fairly certain already that the group number system can be used for nearly all non-variable components and it is expected that the group number system will play an important part in the component trade, because it is related to both component testing and the extreme conditions of use the component is expected to stand up to. It should of course always be remembered that it can be a great help to the equipment designer, but never a substitute for experience.

	first digit					second digit	third digit			
test	dry cold	bumping	vibr.	rapid temp. change	low air press.	dry heat	humidity	accel. humidity	mould growth	salt mist
4	-55 °C	x	x	x	85 mbar	100 °C	84 days	6 days	x	x
5	-40 °C	x	x	x	300 mbar	85 °C	28 days	2 days	-	-
6	-25 °C	x	x	-	-	70 °C	7 days	-	-	-
7	-10 °C	x	-	-	-	55 °C				

Finally a summary of the subjects which are now under consideration is given.

The specification for D.C. capacitors has been accepted for publication.

The following specifications have been circulated under the six-months' rule, meaning that they are in a final stage:

Ceramic dielectric capacitors (D.C. types) for temperature compensation and general tuning purposes (so-called type I)

Electrolytic capacitors

The following subjects are in the discussion stage or will shortly be submitted for discussion:

Fixed carbon resistors
Mica dielectric capacitors
Shaft dimensions and fixing dimensions of variable resistors etc.
Quartz oscillator crystals
H.F. Cables
Plugs and sockets (both audio and radio frequency types)
Radio interference suppression capacitors

Characterization of the noise of tubes and transistors by four measurable quantities

by H. Groendijk and K. S. Knol *)

Lecture delivered before the Nederlands Radiogenootschap on November 5th, 1954

SUMMARY

The noise of a neutralized triode is first calculated by investigating the mechanism of noise production and then by regarding the triode as a linear four-terminal network. It appears, from the first method, that the physical quantities connected with the generation of noise may not readily be determined. The second method shows, however, that it is still possible to characterize the noise by four measurable quantities and, if once these are known, to calculate the noise factor. This holds for any linear four-terminal network, triodes, pentodes, transistors, etc. In general, no simple relationship exists between these quantities and the physical properties giving rise to noise. In the case of a triode the four noise quantities depend on frequency in a simple way.

1. *Resistance noise.*

Though the term noise is originally derived from acoustics it is now generally used for random fluctuations of current or voltage as occurring in resistances, tubes, transistors, etc. Let us first consider a resistance R (fig. 1a). If we do not connect a voltage source in series or in parallel with this resistance, a voltage still appears to exist between the terminals. This voltage is continuously fluctuating in amplitude and polarity. For a finite time

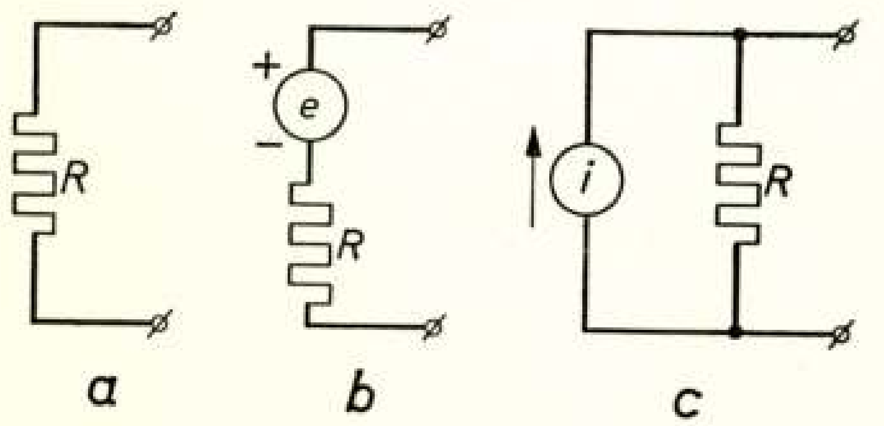

Fig. 1.
A resistance R and its equivalent noise circuits.

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interval this noise voltage may be expressed in terms of a Fourier integral [1]. We next consider only the contribution to this integral of those frequencies which lie between the frequencies f and $f + \triangle f$. The physical interpretation of this procedure is, that we put between the noise source and the measuring device a filter having that passband with a rectangular characteristic.

Up to very high frequencies the noise energy present in the frequency interval $\triangle f$ appears to be proportional to $\triangle f$ and independent of the frequency f itself. The noise energy produced by the resistance R may be calculated by regarding it as a voltage source (fig. 1b) with an internal resistance R and a noise e.m.f. e the mean square value of which is

$$\overline{e^2} = 4\,kTR\,\triangle f \tag{1}$$

From Thévenin's theorem it follows that this voltage source is equivalent to a noise current source (fig. 1c) having an internal conductance $g = 1/R$ and a short-circuit current i with a mean square value of

$$\overline{i^2} = 4\,kTg\,\triangle f \tag{2}$$

2. *Tube noise.*

We shall now deal with the noise of tubes. Let us first consider the physical aspect and discuss the causes of noise inside the tube. This is the way one began to study tube noise when for the first time it became important. In section 5 we shall consider this problem from a more formal point of view by starting with the noise of linear four-terminal networks. For signal and noise voltages and currents in a rather narrow frequency band and with small amplitudes, amplifying tubes are indeed linear four-terminal networks and it will be shown that with this treatment of tube noise certain difficulties appearing in the physical treatment do not occur.

3. *Physical noise sources.*

To simplify our treatment of the physical noise sources in an amplifier tube we confine ourselves to a neutralized triode in a grounded-cathode circuit. By „neutralized" is meant that the capacitance between grid and anode is tuned. As we are only interested in alternating currents and voltages we omit the direct

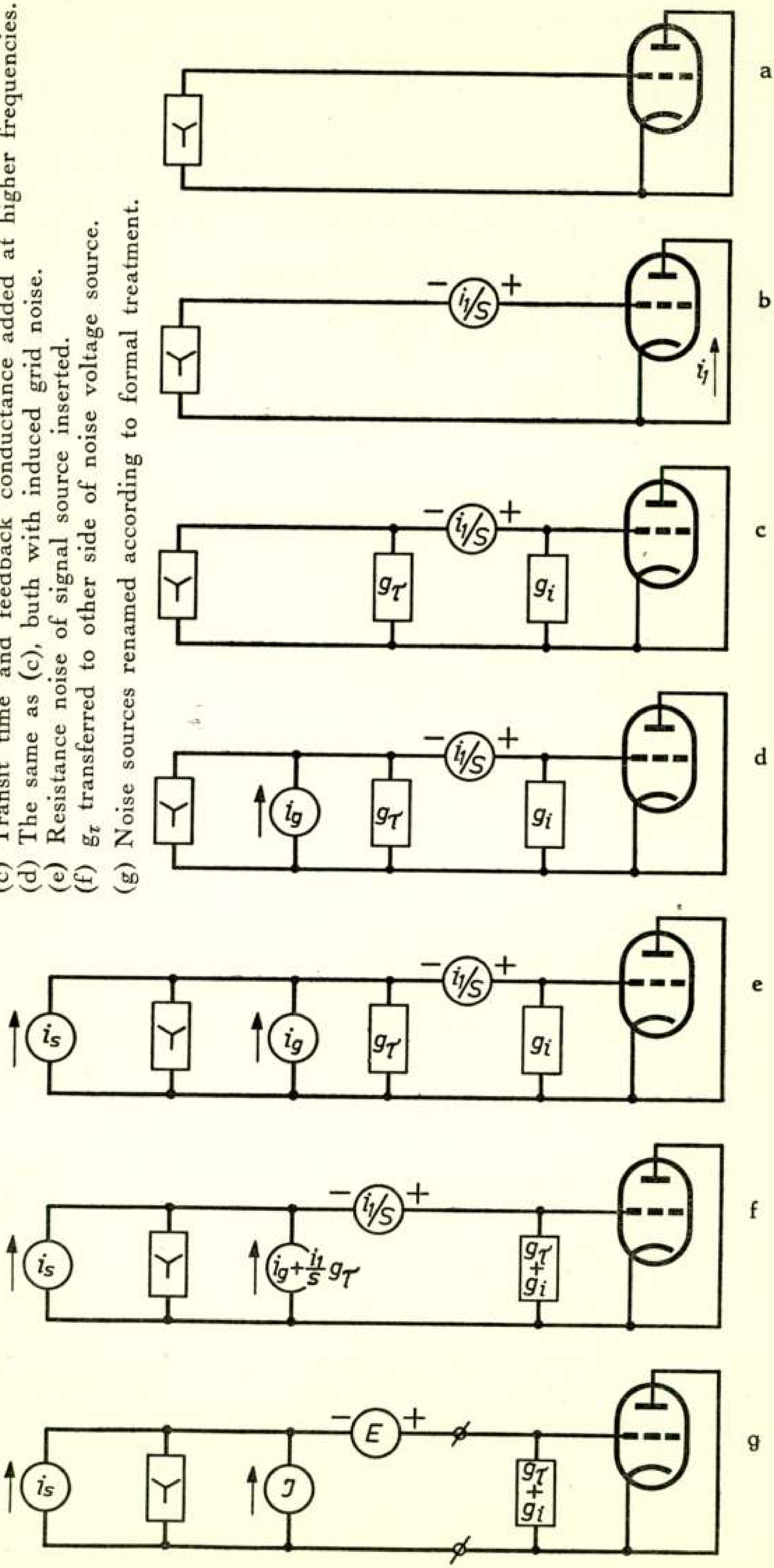

Fig. 2.
(a) Neutralized triode. Equivalent circuit without noise.
(b) Equivalent circuit at low frequencies with shot noise.
(c) Transit time and feedback conductance added at higher frequencies.
(d) The same as (c), buth with induced grid noise.
(e) Resistance noise of signal source inserted.
(f) g_τ transferred to other side of noise voltage source.
(g) Noise sources renamed according to formal treatment.

current and voltage sources. Further it is easily proved by theory that the anode load does not affect the noise performance of a tube. For that reason the output has been short-circuited (fig. 2a). Across the input of the tube a signal source (e.g. an antenna) and a tunable circuit are connected having a total admittance Y.

3.1. *Low-frequency noise.*

We consider first the noise behaviour of the tube at low frequencies. If we put such direct voltages between the electrodes that a direct current is flowing in the output lead, superimposed upon this direct current a fluctuating current i_1 is also present (fig. 2b). This noise current i_1 is caused by the electrons being thermally emitted from the cathode. It is called the shot noise current. At low frequencies the tube noise can be ascribed to this effect only. The triode noise may therefore be described by giving the mean square value $\overline{i_1^2}$ of i_1. However, it is common practice to describe it in another way. i_1 can be thought of as being generated by a noise voltage i_1/S in the input lead, if S is the mutual conductance. This voltage source may be characterized by the value of the resistance giving the same noise e.m.f. This resistance is called the equivalent noise resistance R_{eq}. If we consider again only the contribution to the noise of the frequencies between f and $f + \triangle f$, we have, according to (1),

$$\overline{i_1^2}/S^2 = 4\,kTR_{eq}\,\triangle f \tag{3}$$

3.2. *Triode at higher frequencies.*

The noise behaviour of a tube at low frequencies is thus rather simple, it being described by one quantity, the equivalent noise resistance. At higher frequencies, however, the phenomena become more intricate. Then we have to take into account that the transit time of the electrons in the tube is no longer negligible as compared with one period of the frequency considered.

3.21. *Transit time conductance.*

To investigate the effect of the electron transit time we first put between grid and cathode an alternating voltage which is so large that the noise currents do not play an appreciable part. An alternating electron current will then start from the cathode, and will induce a current in the input lead flowing from cathode to grid. After the electrons have passed the grid a current from grid to anode is induced (fig. 3). At low frequencies both currents in the input lead cancel. At high frequencies, however, we have to take into account that these currents no longer have exactly opposite phases. A current is therefore produced in the grid-cathode circuit and it may be shown that the direction of this current is such, that the signal source has to supply energy. In other words, at these frequencies there is an extra conductance over the input of the tube, the so-called transit time conductance g_τ. We insert this conductance in our equivalent circuit (fig. 2c). The effect of the induced grid currents on the noise is accounted for separately in 3.23 for the reasons discussed there. We therefore have to connect g_τ in such a way in the equivalent circuit that it acts only on the signal and not on the noise, i.e. it has to be placed before the fictitious noise voltage source i_1/S.

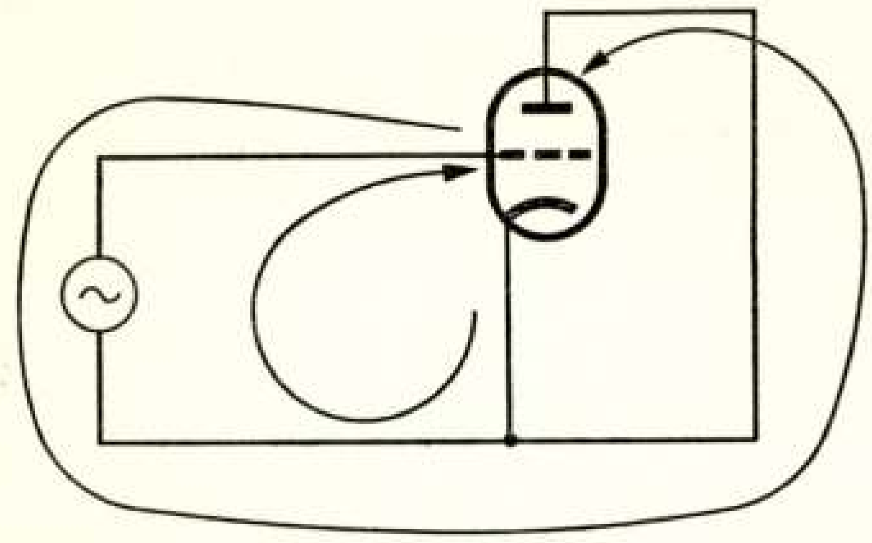

Fig. 3.
Induced currents flowing in a triode when an electron is going from cathode to anode.

3.22. *Feedback conductance.*

There is yet another conductance appearing at high frequencies. It is caused by the self-inductance of the cathode lead. The output current flows through this lead, and as the latter is common to output and input circuits an additional voltage is created in the input circuit. This feedback can be represented by a real admittance g_i. This holds for the signal as well as for the noise. For that reason g_i has to be placed in the equivalent circuit behind the noise source (fig. 2c).

3.23. *High frequency noise.*

Like the signal currents the shot noise current flowing between cathode and anode successively gives currents in the outer leads from cathode to grid and from grid to anode. If we call these currents i_0 and i_1 respectively, the current flowing into the grid is a noise current $i_g = i_1 - i_0$. The way in which this noise current is produced, however, differs from that in which the induced signal current, treated in 3.21, is generated. In the latter case an alternating voltage is put between grid and cathode, influencing the electrons when they pass from cathode to anode. But the noise voltage source i_1/S is not actually present; it is only a fictitious source used to represent the shot noise current in the output lead. Therefore, the induced noise current i_g cannot be represented in the same way as the induced signal current by means of the transit time conductance, so we have to introduce a separate noise current source i_g (fig. 2d).

3.3. *Aerial noise.*

To complete our equivalent circuit we must still introduce the noise produced by the real part of Y. Y is the sum of the admittances of signal source and input circuit (a coil and a capacitor). To simplify the formulae we neglect the conductance of the input circuit, as it is small compared with that of the signal source. In most cases this is allowed. We write $Y = g + jb$, where g is called the source conductance and b the circuit susceptance. For the first tube of a receiver, g is the transformed antenna conductance. Our considerations, however, hold for the second and following tubes as well.

The source conductance g produces resistance noise which may be represented by a noise current source i_s (fig. 2e). According to formula (2) we have $\overline{i_s^2} = 4\,kTg\,\Delta f$.

4. *The noise factor.*

In the equivalent circuit of fig. 2e the noise properties of the tube are represented by two noise sources in the cathode-grid circuit. The tube itself should then be assumed to be noiseless. However, we are generally not interested in the noise itself, but in the ratio of noise power P_n and signal power P_s. A tube increases this value since the P_n and the P_s that are available at the input are amplified by the same factor and the tube produces excess noise. So if we compare the ratio of the noise power P_n and the signal power P_s that are available at the output with the same ratio at the input, the first one is largest. The quotient of these two noise-to-signal ratios is called the noise factor F [2]. We have

$$F = \frac{P_{no}}{P_{so}} : \frac{P_{ni}}{P_{si}} = \frac{P_{no}}{G} : P_{ni} \tag{4}$$

where $G = P_{so} : P_{si}$ is the power gain. P_{ni} is proportional to the mean square of the noise current arising from the signal source:

$$P_{ni} = k\,\overline{i_s^2}\,. \tag{5}$$

P_{no}/G, the output noise power divided by the power amplification factor, is the noise power we should have to apply at the input of a noiseless tube in order to get the noise power P_{no} at the output. So P_{no}/G is proportional to the mean square of the noise current produced by all equivalent noise sources at the input together. This noise current is $i_s + i_g + \frac{i_1}{S}(Y + g_\tau)$, since the voltage source $\frac{i_1}{S}$ in series with the admittance $Y + g_\tau$ is equivalent to a current source $\frac{i_1}{S}(Y + g_\tau)$ in parallel with $Y + g_\tau$. We have thus

$$P_{no}/G = k\,\overline{\left\{i_s + i_g + \frac{i_1}{S}(Y + g_\tau)\right\}^2} \tag{6}$$

By substituting (5) and (6) in (4) we obtain the formula for the noise factor

$$F = \frac{\overline{\{i_s + i_g + (i_1/S)(Y + g_\tau)\}^2}}{\overline{i_s^2}} \tag{7}$$

We could now evaluate F if we knew:

(1) The shot noise $\overline{i_1^2}/S^2$ or R_{eq},
(2) The induced grid noise $\overline{i_g^2}$,
(3) The transit time conductance g_τ and
(4) The correlation between i_1 and i_g.

But if we look for the tube data in a handbook we only find R_{eq} if even that. The usual way to proceed is, then, to calculate g_τ from the dimensions of the tube. From the value of g_τ thus found, $\overline{i_g^2}$ may be calculated using a theoretical formula derived by Bakker [3]. The correlation is not taken into account at all. The formulae used are based upon simplifying assumptions, a.o. ideal triode. The transit time conductance can neither be measured accurately as we are only able to measure the total input conductance $g_\tau + g_i$.

When using tubes in circuits we are not in the first place interested in the physical causes of the noise in these tubes, but we should like to have at our disposal such data that we could calculate the noise factor of a tube for any input circuit. This result has not been obtained with the above considerations. Though we have derived a formula for the noise factor we cannot evaluate it since we do not know several quantities occurring in this formula and, above all, we do not know for certain that other effects not taken into account in the theory, may be neglected. An investigation of the physics of noise production is, of course, very important if we want to make low-noise tubes. But we do not concern ourselves with this problem here.

5. *Noise of four-terminal networks.*

We therefore shall start with another method. For small signal and noise amplitudes and in a narrow frequency band

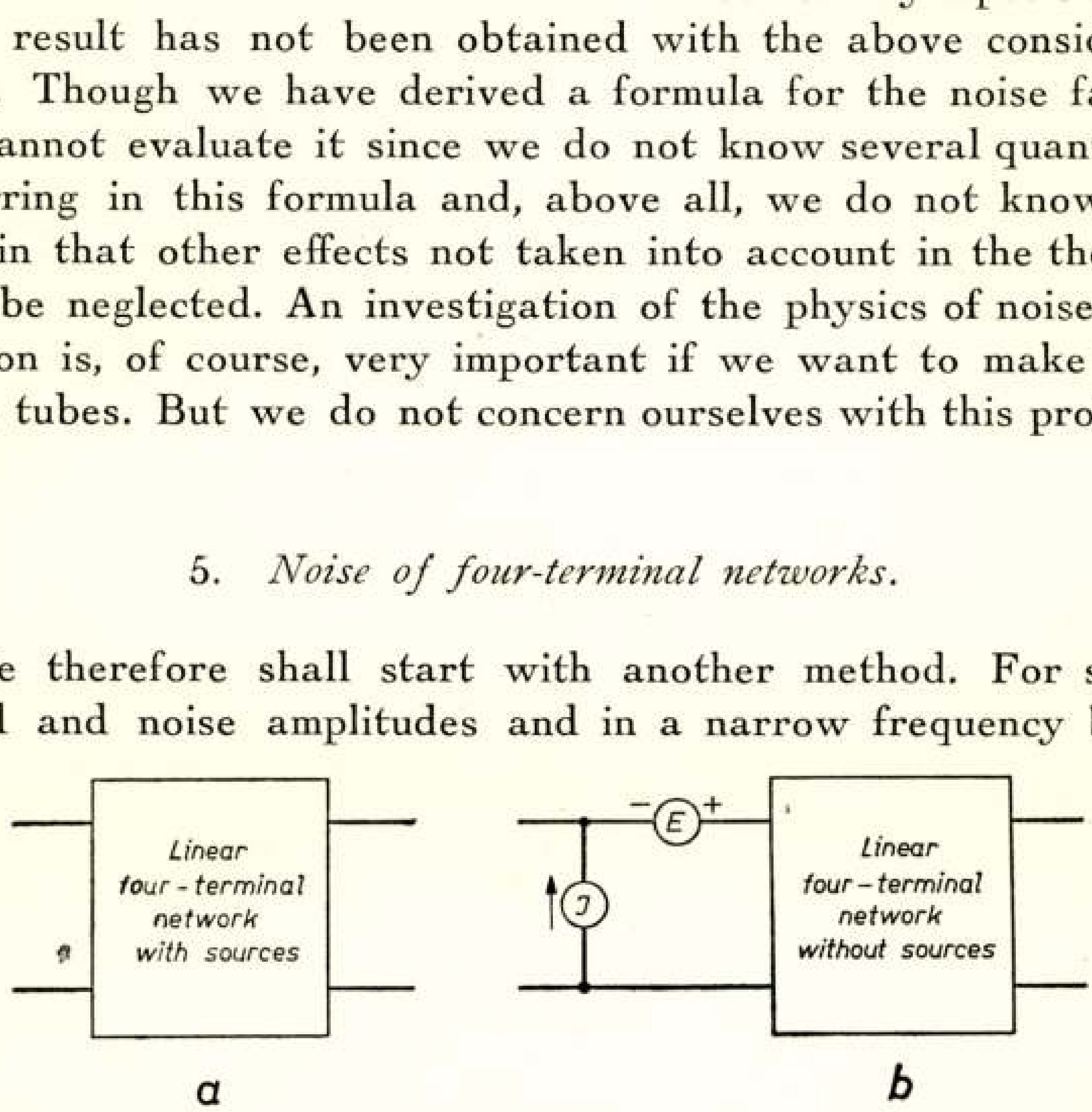

Fig. 4.

A linear four-terminal network containing voltage and current sources (a) is equivalent to a network without internal sources (b), but with a voltage source E and a current source J across the input. The second network is derived from the first one by omitting all the internal sources.

Δf around a frequency f, tubes, transistors, amplifiers etc. may be regarded as linear four-terminal networks (fig. 4a). In the theory of linear four-terminal networks with internal current and voltage sources [4] it is known that the effect of these sources can be regarded as being caused by a voltage and a current source across the input (fig. 4b). So an active linear four-terminal network with internal sources is equivalent to the same network without sources, but with these two sources E and J connected across the input.

This theorem, which resembles the theorem of Thévenin for two-terminal networks, was used recently by Becking to represent the noise behaviour of transistors. He showed that with the aid of this theorem, a formula for the noise factor can be derived, containing only measurable quantities.

We shall not give a proof of this theorem here, but we shall only show its validity for the idealized triode that has been treated in section 3.

5.1. *The idealized triode as a four-terminal network.*

If we compare the equivalent circuit derived by the physical treatment (fig. 2e) with the circuit in terms of E and J (fig. 4b), they appear, at first sight, nearly the same; however, there is one important difference, viz. in fig. 4b both noise sources are connected across the input of the network, while in fig. 2e the noise voltage source is connected between two parts of the input conductance both belonging to the tube. Now this may be changed as follows. We have seen already that the noise voltage source i_1/S in series with $(Y + g_\tau)$ is equivalent to a noise current source $(i_1/S)(Y + g_\tau)$ in parallel with $(Y + g_\tau)$. So the total impressed noise current is

$$i_s + i_g + \frac{i_1}{S}(Y + g_\tau)$$

This, however, may be written as

$$i_s + (i_g + \frac{i_1}{S} g_\tau) + \frac{i_1}{S} Y$$

from which we can infer that the equivalent circuit may also be drawn as in fig. 2f. If we call the noise e.m.f. $i_1/S = E$ and the impressed noise current $i_g + (i_1/S) g_\tau = J$, we get fig. 2g where both noise sources are connected across the input terminals of the tube just as in the formal noise circuit of Becking.

5.2. *The noise factor in terms of the equivalent sources.*

The noise factor may be expressed in terms of E and J. It has been shown already that F is the mean square of the total equivalent impressed noise current at the grid divided by $\overline{i_s^2}$. Hence

$$F = \frac{\overline{(i_s + J + Y \, . \, E)^2}}{\overline{i_s^2}} \tag{8}$$

In this formula occurs $Y . E = gE + jbE$. Here $jbE = b . jE$ is a noise current obtained by first changing the phase of each Fourier component of the noise in the frequency interval $\triangle f$ considered by a quarter of a period of its own frequency and then multiplying it by the susceptance b. Then we get for the mean square of $Y . E$ the expression $(g^2 + b^2) \overline{E^2}$ as $\overline{(jE)^2} = \overline{E^2}$ (the phase shift does not affect the mean square value of E) and $\overline{E . jE} = 0$ (the mean of each sine-function multiplied by the corresponding cosine-function vanishes).

i_s is not correlated with either J or E. However, J and E may be partly correlated. So the mixed terms are zero except for $2 \overline{J . YE} = 2 g \overline{J . E} + 2 b \overline{J . jE}$. Then we get for F

$$F = 1 + \frac{\overline{J^2} + (g^2 + b^2) \overline{E^2} + 2 g . \overline{JE} + 2 b . \overline{J . jE}}{\overline{i_s^2}} \tag{9}$$

For $\overline{i_s^2}$ we have the expression (2) : $\overline{i_s^2} = 4 \, kTg \triangle f$.

Formula (9) holds for any linear four-terminal network. It contains four quantities characterizing the noise, viz. $\overline{J^2}$, $\overline{E^2}$, $2 \overline{JE}$ and $2 \overline{J . jE}$. These quantities may be determined by measuring F for four different values of $g + jb$. This may be accomplished by connecting a saturated diode across the input. The shot noise produced by such a diode if a direct current is flowing through it, is exactly known, and it may be compared with the total equivalent impressed noise current of the tube by measuring the noise output power with this diode turned on and off. If once the four noise quantities have been measured in this way, F may be evaluated for any circuit or antenna admittance Y.

5.3. *Results of the formal treatment.*

By this formal treatment of noise we have obtained two results:

(1) Though formula (7) for F, derived by the physical treat-

ment, is essentially the same as formula (8), derived by the formal treatment, we see now that these formulae contain measurable quantities. These quantities, however, can only be given a physical interpretation if we have a theory for the way in which the noise is produced. For example, E corresponds to the shot noise current divided by the mutual conductance in the simplified theory of section 3. But, in reality, other noise sources, not incorporated in this theory, may also contribute to E.

(2) Formula (7) was derived by idealizing the processes of noise production in a triode. But now we have a formula that is independent of any physical theory. Besides using formula (9) for the evaluation of F as mentioned above, we may also use it to test a noise measuring equipment. We see for example that for constant g, F is a quadratic function of b and that for constant b, the formula gets the form $F = A + Bg_s + Cg_s^{-1}$.

6. *The characteristic noise quantities.*

From the four noise quantities defined by formula (9), viz. $\overline{E^2}$, $\overline{J^2}$, $\overline{JE}$ and $\overline{J\,.\,jE}$, we shall deduce other quantities in order to simplify the formula for the noise factor and to obtain quantities whose significance is more easily understood. As we have seen $\overline{i_s^2}$ depends on $\triangle f$. Since the noise factor is independent of the bandwidth used if it is small enough, the noise quantities defined also depend on $\triangle f$. As F does not depend on $\triangle f$, it is recommendable to define the noise quantities from which F is calculated in such a way that they do not contain $\triangle f$ either. For that reason we shall deduce other noise quantities from those already defined.

6.1. *The equivalent noise resistance* (R_{eq})

As has been shown in section 5.1., for triodes E is equal to the equivalent noise voltage source i_1/S, that is represented by the equivalent noise resistance R_{eq}. Therefore we shall use this definition generally. So a characteristic noise quantity R_{eq} is introduced that is defined by

$$\overline{E^2} = 4\,kTR_{eq}\triangle f \qquad (10)$$

6.2. *The minimum noise detuning capacitance* ($\triangle C$)

As already noted in 5.3., F is a parabolic function of b, the susceptance of the input circuit. As the coefficient $\overline{E^2}$ of b^2 is positive, F has a minimum for a certain value of b, called b_{opt}. From (9) it follows that

$$b_{opt} = -\frac{\overline{J.jE}}{\overline{E^2}} \tag{11}$$

But b_{opt} itself can not easily be measured. It is better to measure the difference of b_{opt} and a readily recognizable value of b, for example b_{res}, the value of b for tuned input circuit. If we write $b_{opt} - b_{res} = \omega \triangle C$ we may regard $\triangle C$ as a characteristic noise quantity. $\triangle C$ is called the minimum noise detuning capacitance. It expresses the well-known fact that the noise factor may be decreased by detuning the input circuit.

6.3. *The noise correlation number* (ζ).

In formula (9) the terms that are independent of the admittance of the input circuit are

$$1 + \frac{2\,\overline{JE}}{4\,kT\triangle f} = 1 + \zeta \tag{12}$$

The second term is a real number that we call ζ, the noise correlation number. ζ and $\triangle C$ are both quantities taking care of the correlation of the noise sources.

The accuracy of noise factor measurements is mostly not better than 0.1. Therefore, if ζ is smaller than 0.1 it may be neglected. From triode noise theory it follows that this is certainly the case up to frequencies of 300 Mc/s. For transistors, however, even at very low frequencies ζ may not be neglected.

6.4. *The minimum noise factor* (F_{min}).

We have yet to find a more convenient quantity for $\overline{J^2}$. For this we use the minimum value of F obtained by varying both b and g. We have seen already that then we must make b equal to b_{opt}. The dependence of F on g is given by

$$F = A + Bg + \frac{C}{g} \tag{13}$$

For a certain value of g, called g_{opt}, F reaches its minimum value F_{min}. Decreasing F by varying the value of g is called noise matching. Generally this value g_{opt} of g is not the same as is needed for power matching.

The minimum value of F may be calculated from (9) and we get an expression for F_{min} in terms of $\overline{J^2}$ and the three other noise quantities. On the other hand we may also express $\overline{J^2}$ in terms of R_{eq}, $\triangle C$, ζ and F_{min}.

6.5. *The formula for the noise factor.*

Substituting the new quantities in (9), we obtain by straightforward algebra

$$F = 1 + \zeta + \frac{R_{eq}}{g} \left[g^2 + (b - b_{opt})^2 + \left(\frac{F_{min} - 1 - \zeta}{2\, R_{eq}} \right)^2 \right] \qquad (14)$$

Of course, the choice of these quantities is somewhat arbitrary. We might also have taken other combinations of $\overline{J^2}$, $\overline{E^2}$, $\overline{JE}$ and $\overline{J\,.\,jE}$ to use them as characteristic values. We get, for instance, an even simpler formula if we introduce g_{opt} instead of F_{min}. Calculating g_{opt} from (14), we find

$$g_{opt} = \frac{F_{min} - 1 - \zeta}{2\, R_{eq}} \qquad (15)$$

so that the formula for the noise factor becomes

$$F = 1 + \zeta + \frac{R_{eq}}{g} \left[g^2 + g_{opt}^2 + (b - b_{opt})^2 \right] \qquad (16)$$

On the other hand F_{min}, being the lowest obtainable noise factor, gives a good measure of the performance of a low-noise tube. For that reason we prefer to use F_{min}, rather than g_{opt}, as a characteristic noise quantity.

7. *Frequency dependence of the noise quantities.*

The noise quantities depend on frequency. However, this dependence is fairly simple in the case of triodes, which are mostly used as first tubes of h.f. amplifiers because of their low noise factor. This dependence may be derived from the theory given in section 3. Though several effects have not been taken care of in this theory we may assume that the frequency dependence holds good for a frequency change which is not too great. This frequency dependence is

(1) R_{eq} is independent of f,
(2) $\triangle C$ is independent of f,
(3) ζ vanishes and
(4) $F_{min} - 1$ is proportional to f.

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Internationale Kustverlichtingsconferentie te Scheveningen

door C. B. Broersma *)

SUMMARY

The „International conference on lighthouses and other aids to navigation" took place at Scheveningen (Holland) on 31st May — 9th June 1955.

A synopsis of the documents, reports and following discussions, particularly related to electronical navigational aids such as: Radar, Loran, Consol, Radarbeacons, Radio range beacons, Radiocommunication etc. is given below.

Van 31 Mei tot en met 9 Juni j.l. vond te Scheveningen plaats de 5-jaarlijkse *„International conference on lighthouses and other aids to navigation" (Conférence internationale des services de signalisation maritime).*

Het arbeidsveld van deze conferentie, dat zich vroeger praktisch uitsluitend bewoog op het gebied van vuurtorens, bebakening etc., heeft zich thans ook uitgebreid tot dat van de electronische navigatiemiddelen zoals: Radar, Loran, Consol, Radarbakens, Radio-geleidebakens, Radiocommunicatie etc.

Men heeft derhalve de conferentie, welke geopend werd in het Kurhaus te Scheveningen door Zijne Excellentie Minister Staf, gesplitst in twee commissies:

Commissie A, welke de vuurtorens, lichttechniek, bebakening, boeien etc. behandelde, en

Commissie B, welke de electronische navigatiemiddelen en geluidssignalen onder de loupe nam.

Met algmene stemmen werd tot Voorzitter der Conferentie, tevens Voorzitter van Commissie A benoemd: Ir. P. G. J. van Diggelen, Hoofd van de Technische Dienst van 's Rijks Kustverlichting, en tot Voorzitter van Commissie B: Ir. M. H. W. Moorrees, Ingenieur Eerste Klasse van de Technische Dienst van 's Rijks Kustverlichting. Beide voorzitters hebben met grote

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bekwaamheid de discussies geleid en op voortvarende wijze — waar dit nodig was — overbodige toelichtingen, welke enkele conferentieleden dreigden te geven, beperkt. Zonder deze voortreffelijke leiding, zou men nimmer in staat geweest zijn gedurende de vijf „werkdagen" der conferentie de circa 70 documenten te behandelen.

De wijze waarop de voorzitters, door middel van korte uittreksels, de agendapunten inleidden werd door een ieder ten zeerste gewaardeerd.

Steller dezes heeft uitsluitend de vergaderingen van Commissie B bezocht en, daar deze in de eerste plaats de belangstelling zullen hebben van de leden van het N.R.G., blijft het navolgende verslag uitsluitend beperkt tot de handelingen van Commissie B.

I. *Secundary aids to radar navigation in the centimetric band*

De navigatie met behulp van scheepsradarinstallaties kan belangrijk gesteund worden door het toepassen van „radarbakens". Zulke bakens dienen geplaatst te worden op plaatsen langs de kust, welke onvoldoende radarinformatie geven, op lichtschepen etc.

Met betrekking tot zulke radarbakens kunnen twee verschillende ontwikkelingen worden gerapporteerd.

a. De Amerikaanse wijze, waarbij het radarbaken werkt op een frequentie die iets verschilt van de frequentie waarop de scheepsradarinstallatie werkt. De „bakeninformatie" kan dan op het radarscherm slechts geproduceerd worden door een toevoeging aan de radarontvanger (tweede locale oscillator).
b. De wijze toegepast in Engeland en Nederland, waarbij de bakenzender werkt op een frequentie gelijk aan de scheepsradarinstallatie. In dit geval kan het baken worden ontvangen zonder voorzieningen aan de radarontvanger.

Bovendien kwam de kwestie ter sprake of radarbakens moeten werken op beide, thans in gebruik zijnde, frequenties van radarinstallaties (t.w. 3000 mc/s en 10.000 mc/s) of slechts op de meest toegepaste 10.000 mc/s frequentie. Men was van gevoelen dat zowel 3000 mc/s als 10.000 mc/ bakens moeten worden toegepast.

Betreffende passieve radarbakens (reflectoren) was Nederland van gevoelen dat deze moeten worden gemonteerd op de „lichtboeien", dat zijn dus de belangrijkste boeien, terwijl de kleinere boeien op zodanige wijze dienen te worden geconstrueerd, dat deze goede „radar-reflectie"-eigenschappen bezitten.

II. *Instability, field strength and spectra of Marine Radio Beacons*

Het betreffende rapport, afkomstig van Belgische zijde toont aan dat de stabiliteit van radiobakenzenders in de band van 285—325 kc/s sinds het invoeren van het nieuwe Radiobakensysteem is verbeterd; er wordt echter geconstateerd dat slechts 25 % van deze radiobakens voldoet aan de tolerantie-eis, vastgesteld door de Radioconferentie te Atlantic City 1947.

Tevens wordt geconstateerd dat de veldsterkte van de betreffende Radiobakens sinds 1949 is verminderd. Dit is in overeenstemming met de gemaakte afspraken bij de Conferentie te Parijs in 1951, welke tot doel hadden de storingen, veroorzaakt door de bakens onderling, te verminderen.

Bovendien werd gemeld dat een onrustbarend aantal „aeronautical beacons" binnen de maritieme bakenfrequentieband is verschenen. De conferentie maakte een aanbeveling (resolution) teneinde dit euvel tegen te gaan.

III. *Experiments with a new type of signal composition for marine radiobeacons*

Een rapport van Finse zijde betreffende proefnemingen met een nieuw type signaal ten behoeve van radiobakens, waarbij niet een continu lange streep wordt gegeven doch een signaal met snelle onderbrekingen (in de geest van een „snelzender"), meldt dat met deze „nieuwe methode" nauwkeuriger kan worden gepeild.

IV. *The operation of the new radiobeacon system*

De Engelsen geven hierin een overzicht van de veranderingen welke uitgevoerd werden aan 63 radiobakenzenders teneinde deze aan te passen aan de eisen van de Overeenkomst voor Maritieme Radiobakens Parijs 1951.

V. *Harbour Radar of Le Havre*
Shore based radar systems for ports and waterways in the Netherlands
IJmuiden Radar — Operational Report

Grote belangstelling werd getoond voor deze documenten, één van Franse oorsprong en twee van Nederlandse zijde. De Fransen bleken voor hun havenradar een voorkeur te hebben voor 10 cm golflengte. Zij geven tevens details van de proeven welke in Le Havre werden gedaan met het overbrengen van het beeld van de havenradar met behulp van een televisiezender naar enkele met een televisieontvanger uitgeruste schepen.

Uitvoerige discussies vonden plaats over het al of niet noodzakelijk zijn van een identificatie-systeem in combinatie met walradarsystemen. Van Franse zijde werd te kennen gegeven dat men identificatie eigenlijk niet nodig vond; men zou nimmer last gehad hebben met het identificeren van een schip dat walradar-informatie nodig had.

Echter moet worden erkend dat de gegevens van onze Franse vrienden ietwat vaag waren en dat bleek dat men wel eens grote moeite gehad heeft om uit een aantal, zich op geringe afstand van elkaar bevindende, schepen het juiste schip te vinden.

De discussies over het — per televisie-link — uitzenden van het walradarbeeld resulteerde in een aanbeveling van de conferentie, inhoudende dat het nodig is voor dit doel kanalen te reserveren. Een werkcommissie werd ingesteld welke zal onderzoeken in welke band (U.H.F. of S.H.F.) deze kanalen moeten worden gereserveerd. De West-Duitse delegatie meende dat de S.H.F.-band wel eens de voorkeur zou kunnen hebben; men was bezig met veldsterktemetingen in dit frequentiegebied.

Voorts werd door de Nederlandse delegatie een uiteenzetting gegeven over het operationeel gebruik van havenradar-systemen in combinatie met het Raplot-systeem, waarbij op electronische wijze richting en afstand met grote nauwkeurigheid kan worden gemeten.

Uit een voortgezette zeer interessante discussie bleek dat tijdens mist 20—30 % schepen de havenradar te Le Havre gebruiken; te IJmuiden gebruikt bijna 100 % der schepen de havenradar tijdens mist voor het opzoeken van de ankerplaats of voor binnenkomen, terwijl te Halifax slechts 2 à 3 % van de walradar gebruik maakt. Te Halifax heeft men gebruik gemaakt van een richtingzoeker met kathodestraalbuis voor identificatie-doeleinden.

In Amerika werkt men thans aan een systeem „TVS", genaamd („Triggered Video Synchronising"), waarbij het havenradarbeeld wordt overgebracht naar de scheepsradar. Men behoudt hierbij aan boord de keuze van het „afstandsbereik".

VI. *Radio navigation aids for medium and long distance with special regard to Consol — W.-Duitsland*

VII. *Technological advances in the Loran system — U.S.A.*

Deze documenten worden hier gelijktijdig behandeld omdat zij aanleiding gaven tot een discussie tussen de Amerikaanse delegatie en die van enkele Europese landen over het feit welk van de twee systemen in de praktijk de beste operationele resultaten had gegeven.

De Amerikaanse vertegenwoordiger hield een vurig pleidooi ten gunste van Loran en somde de verbeteringen op welke men gedurende de laatste jaren had weten te bereiken, zoals vermindering van de bandbreedte, automatische synchronisatie en automatisch volgen van de afleesinrichting van de ontvanger. De eenvoud van het Consol-systeem wees hij — min of meer — van de hand door de nauwkeurigheid van dit systeem in twijfel te trekken.

Het hierboven genoemde West-Duitse document beschrijft tevens een nadere ontwikkeling van Consol, „Consolar" genoemd, welke van *vijf* „space diversed" antennes gebruik maakt (i.p.v. *drie* bij Consol), waardoor een uniforme peilnauwkeurigheid over 360° rondom het „Consolar"-station wordt verkregen. Tevens wordt het nachteffect opgeheven, terwijl de „richtingstwijfel" practisch niet meer bestaat.

Interessant is de vermelding dat de Russische delegatie op het gebied van „Consolar" met deskundigheid wist mee te spreken.

VIII. *Note on coarse radiobeacons with loop/aerial systems — Frankrijk*

Radio range beacon of new design for Marine purpose — Zweden

A radio range beacon for dual course-width transmission — Zweden

In bovengenoemde documenten worden baken-systemen beschreven welke in verschillende landen in gebruik zijn en die berusten op het bekende principe van een aequisignaal-sector met een „A—N"- of „L—F"-sector ter weerszijden van de aequisignaal-sector.

In Frankrijk maakt men gebruik van frequenties in de bakenband (circa 300 kc/s), in Zweden maakt men gebruik zowel van de 300 kc/s als de 1600 kc/s band. Gemiddeld afstandsbereik 20 mijl.

Voorts heeft men in Zweden bereikt dat op grotere afstand van het baken een bredere aequisignaal-sector met geringere gevoeligheid — voor het naderen van een haven of vaargeul — wordt verkregen, terwijl op kleine afstand een nauwere aequisignaal-sector met grotere gevoeligheid wordt toegepast.

De — volgens bovengenoemde principes beschreven — bakensystemen hebben — volgens de proefnemingen — een nauwkeurigheid van 2 à 3 graden.

IX. *The possibilities of using the principle and experience of the AGA talking beacon — Zweden*

In Zweden heeft men een baken beproefd in de V.H.F.-band waarbij de peilingen ten opzichte van het baken worden gegeven door middel van het gesproken woord.

Dit geschiedt op de volgende wijze: De richting van de draaiende „beam" wordt iedere 10 seconden uitgesproken. Dit geeft een nauwkeurigheid van $\pm 3°$. Discussies maakten duidelijk dat de nauwkeurigheid kon worden verbeterd tot $\pm 1°$ indien de „draaisnelheid" van de „beam" wordt verkleind. De reikwijdte is beperkt tot iets meer dan „zichtafstand". Aan boord van het schip of het vliegtuig is slechts een V.H.F.-ontvanger nodig. Speciale maatregelen moesten worden genomen om moeilijkheden t.g.v. reflecties door het terrein en „sidelobes" van het antennesysteem te voorkomen.

X. *The microwave lighthouse — Canada*

Dit document beschrijft de reeds bekende experimenten met een 3 cm gericht baken conform het ook in Nederland beproefde principe, beschreven in het Tijdschrift van het N.R.G., Jan. 1954 (deel 19, No. 1). Nieuwe gezichtspunten kwamen niet naar voren.

Het lijkt — gezien overeenkomstige ontwikkelingen in de m.f.-band, zoals beschreven onder VIII — dat dit 3-cm-systeem op de achtergrond zal raken. Immers men heeft aan boord van het schip een speciale ontvanger nodig, welke — voorshands — uitsluitend voor dit speciale baken gebruikt kan worden.

De systemen in de m.f.-band kunnen een communicatie-ontvanger benutten voor algemeen gebruik.

Een discussie over het gevaar dat bij dit type bakens de schepen te veel op één lijn worden geconcentreerd bracht naar voren dat men wellicht met voordeel twee „koerslijnen" kan uitzetten. De ene voor het scheepsverkeer in de ene richting en de tweede voor het tegengesteld gerichte verkeer.

De ervaring in Canada heeft wel geleerd dat tijdelijke afwijkingen van de „beam" kunnen optreden door de nabijheid van schepen. Atmosferische invloeden hadden geen merkbaar effect. Dit bleef beperkt tot fouten in grootte-orde van $^1/_4{}^\circ$.

XI. De Commissie B behandelde eveneens een aantal documenten welke handelen over geluidssignalen en afstandbediening van vuurtorens. Aangezien deze niet van specifiek radiotechnische aard zijn, worden zij in deze bijdrage niet nader behandeld.

XII. Voorts wordt nog melding gemaakt van een ontwikkeling in Finland betreffende een „*Transistorized sunvalve*", ontwikkeld door de Finse Dienst der Kustverlichting. Een „sunvalve" beoogt het automatisch doen onsteken van vuurtorens.

De vuurtorens in Finland zijn meestal uitgerust met de „sunvalve" van Gustav Dalen, welke voor zijn vele ingenieuze vindingen beloond werd met de Nobelprijs. Het blijkt echter dat deze klassieke „sunvalve" vooral voor het „koude licht" van de polaire winter onvoldoende gevoelig is voor de moderne vuurtoren-apparatuur. Derhalve heeft men thans proeven genomen met een „sunvalve" bestaande uit een photo-electrische cel met passende „transistor-versterker", waardoor thans de transistor ook haar intrede heeft gemaakt bij de kustverlichtingstechniek.

XIII. *Radiotelefonische communicatie*

Als algemeen punt dient te worden opgemerkt dat bleek dat een aantal kustverlichtingsdiensten in verschillende landen voor haar communicatie VHF hebben ingevoerd in plaats van de 2 mc/s frequenties. In dit verband is het tevens belangrijk te vermelden dat voor radioverbindingen tussen schepen en walradar-systemen (havenradar) het systeem met draagbare installaties (portofoons) — door de loodsen naar de schepen mede te nemen — in de praktijk minder goed voldoet en dat de voorkeur gegeven wordt aan vaste — aan boord opgestelde — VHF-zend/ontvangers.

De Conferentie achtte het in dit verband van belang dat voor deze doeleinden internationaal overeengekomen frequenties zullen worden gebruikt.

XIV. *Excursies*

Het bovenomschreven werkprogramma der conferentie vond plaats op 31 Mei t/m 4 Juni j.l. Gedurende de laatste dagen (6 t/m 9 Juni) vond een aantal excursies plaats, o.m. een demonstratietocht met een boeienlegger, waarbij een 3-cm-Ramark-systeem werd getoond dat ontwikkeld was door het Nederlands Radar Proefstation te Noordwijk. Dit systeem wijkt ten aanzien van de volgende punten af van soortgelijke, in het buitenland beproefde systemen: Door het toepassen van in verticale richting „space diversed" breed-band slotted antennes wordt het ontstaan van dode zones voorkomen. Door een passende h.f.-modulatie kan de navigator aan boord der schepen de baken-informatie van dit — *in* de 3-cm-radarband werkend — systeem met behulp van de f.t.c (fast time constant of differentiator) van het radarscherm verwijderen.*)

Voorts vonden bezoektochten plaats, o.m. naar Philips en naar de Zuiderzeewerken.

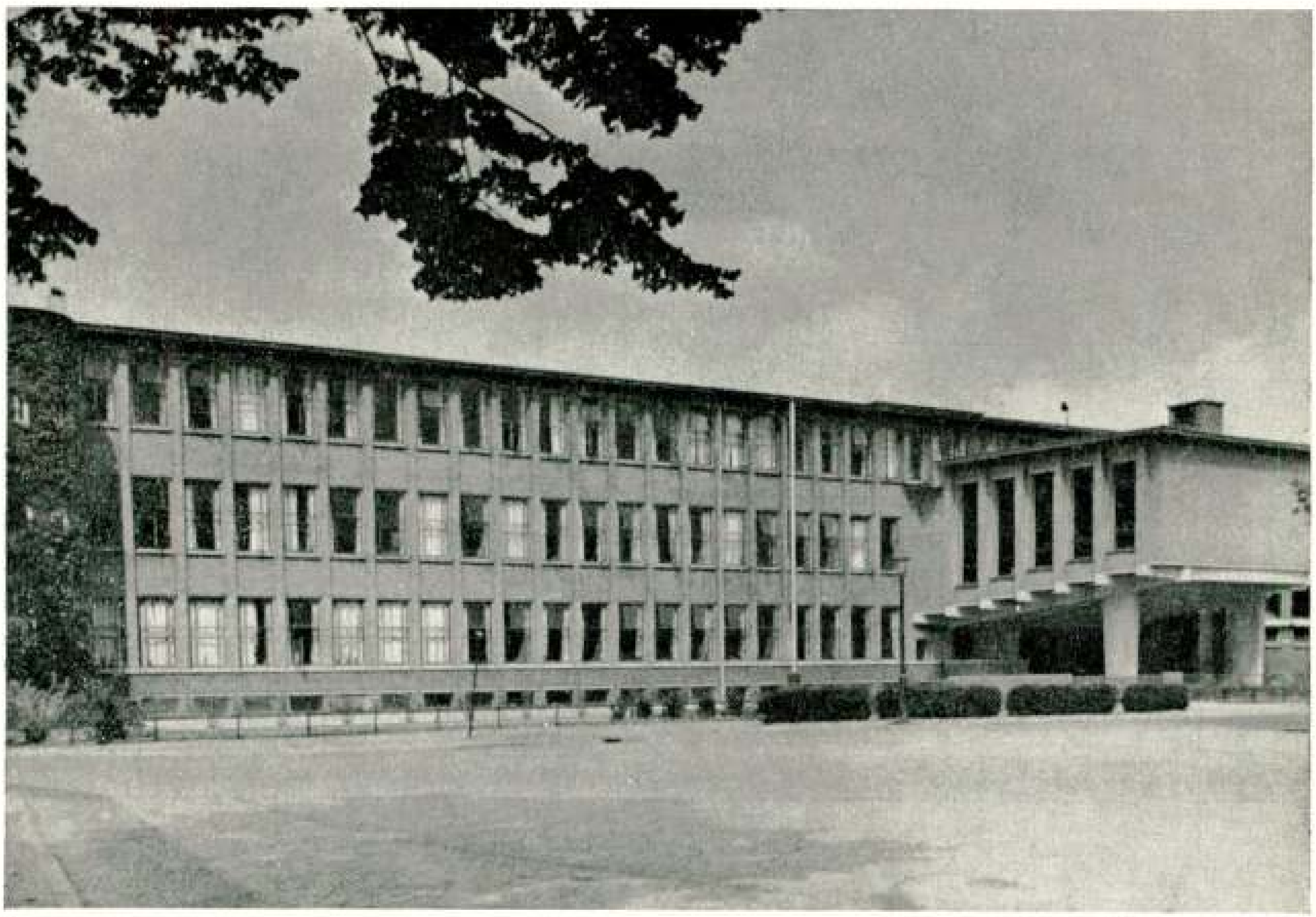
*) Voor nadere bijzonderheden wordt verwezen naar een artikel in het volgende nummer.

OPENING NIEUWE VLEUGEL PHILIPS NATUURKUNDIG LABORATORIUM

Zaterdag 2 Juli is bij de N.V. Philips te Eindhoven, in aanwezigheid van vele autoriteiten, binnen- en buitenlandse gasten, een nieuwe vleugel van het Natuurkundig Laboratorium in gebruik genomen. De opening hiervan werd met technisch ceremoniëel verricht door Z.E. mr J. M. Th. Cals, minister van Onderwijs, Kunsten en Wetenschappen, die daartoe slechts een glas met kleurloze vloeistof in een kolf met rode vloeistof had te schenken. De rode kleur sloeg daarbij om in een groene, die de stralen van een kooldraadlamp, die voordien wèl door de vloeistof gingen, nu tegenhield. Dit had tot gevolg, dat een in de bundel opgestelde fototransistor een relais deed afvallen, waardoor automatisch een foto werd genomen en tegelijkertijd een electronische vertragingsschakelaar in werking werd gesteld. Deze bracht na verloop van een tiental seconden een motortje in beweging, waardoor een keten van gloeilampjes werd ontstoken. Het laatste lampje was een flitslampje, dat bij het ontbranden een geweldige knal deed ontstaan, waarna het gordijn, dat toegang tot de nieuwe vleugel gaf, langzaam werd opengetrokken.

Tijdens een tevoren gehouden bijeenkomst in de nieuwe collegezaal gaf een aantal sprekers uiting aan hun voldoening over de totstandkoming van de uitbreiding en wijdden daarbij bijzondere aandacht aan het feit dat ruim veertig jaar geleden het researchwerk bij Philips werd ter hand genomen. Minister Cals deed aan het eind van zijn rede mededeling, dat het H.M. de Koningin had behaagd bij deze gelegenheid een drietal onderscheidingen toe te kennen.

Prof. dr G. Holst van 1 Jan. 1914—1 Juli 1946 leider en later directeur van het Natuurkundig Laboratorium is voor zijn uitzonderlijke bijdragen op het gebied van het natuurkundig onderzoek en technisch onderwijs in Nederland benoemd tot Commandeur in de Orde van Oranje Nassau. Ir H. Rinia, de oudste der tegenwoordige drie directeuren, is benoemd tot Officier in de Orde van Oranje Nassau, als erkenning voor zijn verdiensten op electrotechnisch en op-



In de ruimte boven de ingang rechts op de foto is de nieuwe Collegezaal ondergebracht. De kamers ernaast (parterre en eerste en tweede etage) zijn zonder uitzondering werkvertrekken voor de wetenschappelijke onderzoekers. De kelderruimte bevat verscheidene vertrekken voor het verrichten van proeven die een constante temperatuur vereisen.

Minister Cals reikt Ir Rinia de nieuw verworven onderscheiding uit.

Met deze handeling verrichtte Minister Cals de opening van de nieuwe vleugel van het Natuurkundig Laboratorium.

tisch gebied, terwijl aan de heer H. J. Lemmens, chef van de glas- en instrumentmakerij en buizenwerkplaats als expert op het gebied van glas- en hoogvacuumtechniek de gouden eremedaille verbonden aan de Orde van Oranje Nassau werd uitgereikt.

Aan de verschillende voordrachten, die ter gelegenheid van de opening van de nieuwe vleugel zijn gehouden, ontlenen wij de volgende bijzonderheden, die vele onzer lezers wellicht zullen interesseren.

In 1914 werd er naast de reeds bestaande laboratoria voor het onderzoek van grondstoffen, het meten van lichtsterkten van gloeilampen enz., een nieuw laboratorium ingericht, waar men ook diepergaande, meer fundamentele onderzoekingen zou kunnen verrichten. De eerste natuurkundigen, die hiervoor werden benoemd, waren Dr G. Holst (op 1 Jan. 1914) en enkele maanden later dr E. Oosterhuis.

Midden in de fabriek op de Emmasingel werd een ruimte uitgezocht, waar men betrekkelijk weinig last van trillingen had en daar werden vier lokalen ingericht als laboratorium, respectievelijk als werkkamer, als studeerkamer, tevens bibliotheek, als instrumentmakerij en als ruimte voor de accumulatorenbatterij.

In 1923 kreeg het Natuurkundig Laboratorium een eigen, nieuw gebouw op het complex Strijp. Dit werd nadien herhaaldelijk uitgebreid, o.a. in 1926, 1929, 1944, 1950 en nu in 1955. Hierbij werd de vloeroppervlakte meer dan vertienvoudigd, namelijk van 2700 m^2 in 1923 gebracht op 27.920 m^2 in 1955, terwijl het aantal werkkamers in die tijd steeg van 100 tot bijna 600.

In 1924 werkten er in het Nat. Lab. 100 mensen, waarvan 15 academici, in 1934 waren het er 370, waarvan 80 academici, in 1946 respectievelijk 700 en 153, terwijl het totaal aantal thans gestegen is tot 1259 en dat der academici tot 250. Gemiddeld bedroeg het aantal academici dus ongeveer 20% van de totale bezetting.

Behalve in Eindhoven werken er ook in het buitenland nog research-groepen, met name in Engeland, de Verenigde Staten en Frankrijk, waardoor het totaal van 1250 man met nog enige honderden moet worden verhoogd. Aan een lunch vertelde Ir Philips dat elke academicus in de research de N.V. in totaal ongeveer *f* 60.000.— kost.

Het wetenschappelijk onderzoek strekt zich over vrijwel de gehele natuurkunde uit en verder over belangrijke gebieden der scheikunde en der ingenieurswetenschappen. Van de academici, die er werken, zijn er thans 44% natuurkundige, 27% scheikundige en 29% ingenieur. Daarbij zijn de natuurkundige ingenieurs en de scheikundige ingenieurs respectievelijk tot de eerste en de tweede categorie gerekend.

Het totaal aantal wetenschappelijke publicaties van de verschillende medewerkers overschreed in 1935 het eerste duizendtal en in 1951 het tweede duizendtal, terwijl het thans ruim 2600 bedraagt. Hiertoe behoren 30 boeken, en 32 dissertaties. Bovendien heeft het Natuurkundig Laboratorium sinds 1936 een eigen publicatieorgaan, het Philips Technisch Tijdschrift, dat elke maand in het Nederlands, Frans, Duits en Engels verschijnt. Daarnaast geeft het sinds October 1945 een eigen tweemaandelijks periodiek uit: de Philips Research Reports.

In de loop der jaren verlieten 18 wetenschappelijke medewerkers het Natuurkundig Laboratorium, omdat zij elders tot hoogleraar werden benoemd, 14 in Nederland en 4 in het buitenland. Bovendien zijn nog 5 medewerkers als buitengewoon hoogleraar met een bijzondere leeropdracht aan een onzer universiteiten of hogescholen werkzaam.

Toen op 1 Juli 1946 Prof. Dr G. Holst als Directeur van het Nat. Lab. aftrad, werd de directie overgenomen door een driemanschap, bestaande uit de natuurkundige Prof. Dr H. B. G. Casimir, de electro-technicus Ir H. Rinia en de scheikundige Dr E. J. Verweij, terwijl in 1947 de scheikundige Dr H. Bienfait als adjunct-directeur daaraan werd toegevoegd.

M. P. V.

NIEUWE UITGAVEN

De redactie ontving de volgende nieuwe uitgaven:
Second Thoughts on Radio Theory door „Cathode Ray".
Toepassingsmogelijkheden en de toekomstige ontwikkeling van de Telexdienst en de telegraafhuurlijnen door T. Perry.
Television Receiver Servicing (deel 2) door E. A. W. Spreadbury.

Boekbespreking

Elsevier's Dictionary of Television, Radar and Antennas door W. E. Clason. Uitgegeven door Elseviers Uitgeversmaatschappij, Amsterdam. 760 pag., 23 x 15 cm. Prijs *f* 62.50.

Dit boekwerk bevat in de eerste plaats — in alphabetische volgorde — in de Engelse taal, een lijst van 2456 technische termen gevolgd door een definitie en een vertaling van de Engelse term in het Frans, Spaans, Italiaans, Nederlands en Duits. Bovendien bevat het werk in de vijf laatstgenoemde talen een alphabetische lijst welke refereert naar de Engelse lijst.

Bij het bestuderen van de lijst blijkt dat zij niet volledig is en voorts dat de definities soms onjuist zijn.

Enkele voorbeelden zijn:

Nederlands: Consolradarsysteem, Engels: Consol beacon system. Opgemerkt zij dat Consol beslist geen radarsysteem is. Definities van geheel verschillende aard worden b.v. gegeven van het Gee-systeem enerzijds en van het Loransysteem anderzijds, terwijl zij een gelijk principe betreffen. In het Nederlands wordt de term „Gee-radarsysteem" gebruikt, terwijl gesproken wordt van een „Loran hyperbolisch stelsel". Naar mijn mening is Gee ook een hyperbolisch stelsel.

De Engelse term „gain control, volume control" wordt in het Nederlands geluids(sterkte) regelaar genoemd.

De definitie van „gain control" luidt: Means for controlling the amplitude of the sound signal. Men kan veel meer zaken dan geluidssterkte regelen met een „gain control".

Het Engelse woord „Direction finder" wordt vertaald in „Richtingpeilstelsel", terwijl Richtingzoeker of Radiopeiltoestel reeds algemeen burgerrecht heeft verkregen en in vele andere woordenlijsten wordt genoemd.

Hetzelfde geldt voor de term „Zeesluier". „Zeekaatsing" wordt allerwege gebruikt en deze term komt dan ook voor in het ontwerp „Benamingen op het gebied van de radiopeiling en radioplaatsbepaling van het Nederlands Electrotechnisch Comité".

Termen als „Frequency modulated radar", „reciprocal bearing" mankeren.

Wat betreft het noemen van verschillende systemen in de richtingzoekertechniek wordt opgemerkt dat de naam „Bellini Tosi" geheel ontbreekt doch wel „Adcock" en „Robinson" zijn opgenomen.

Het is jammer dat nu reeds blijkt dat deze woordenlijst in belangrijke mate zal afwijken van de woorden- en definitielijst welke door het „C.C.I.R." bewerkt wordt en welke ongetwijfeld — als publicatie van de International Telecommunication Union — straks als de officiële erkend zal worden.

Tot de publicatie van deze lijst voorziet de, hierboven besproken, Elsevier uitgave zeker in een behoefte.

C. B. Br.

Guide to Broadcasting Stations 1955—1956. Samengesteld door de staf van Wireless World. 8ste uitgave. Gepubliceerd door Iliffe & Sons Ltd. 18½ x 11½ cm, 80 bladzijden. Prijs 2 sh. 6 d.

Sinds de publicatie van de laatste editie hebben er talloze wijzigingen plaats gevonden. Deze zijn alle in de achtste editie verwerkt. De 650 middengolfomroepstations in Europa zijn zowel naar frequentie als geographisch gerangschikt. De stations die werken op frequenties welke niet zijn toegewezen door het Kopenhagen plan zijn speciaal gemerkt (omstreeks 50%!).

Alle kortegolf omroepstations van de wereld — ongeveer 1600 — zijn op dezelfde wijze aangegeven, terwijl bovendien de roepletters vermeld zijn.

Bovendien geeft deze handige uitgave een opsomming van de meer dan 300 v.h.f. stations en de 130 televisiezenders die in Europa in bedrijf zijn.

Uit het Nederlands Radiogenootschap

PERSONALIA

Dr Ir J. P. POLEY

Op 29 Juni j.l. promoveerde te Delft ons lid J. P. Poley. Promotor was Prof. J. H.de Boer, de titel van het proefschrift luidt: Microwave dispersion of some polar liquids.

Johannes Philippus Poley, geboren 28 Juni 1924 te Bandoeng, behaalde in 1942 het einddiploma H.B.S.-B aan het Chr. Lyceum te Haarlem. Na eerste inschrijving in datzelfde jaar aan de T. H. te Delft, kon hij de studie aldaar in 1945 hervatten, waarna hij in 1948 het diploma van natuurkundig ingenieur verkreeg. Sinds 1947 is hij, met een onderbreking voor militaire dienst, verbonden aan het Physisch Laboratorium der Rijksverdedigings Organisatie - T.N.O., waar hij per 1 Januari 1953 werd benoemd tot hoofdingenieur.

EXAMENS

Verslag van het examen voor radiotechnicus, radiomonteur en televisie-technicus gehouden in April, Mei, Juni en Juli 1955.

De schriftelijke examens voor radiotechnicus, radiomonteur en televisietechnicus werden gehouden op 12 en 13 April 1955. Aangemeld hadden zich 178 candidaten voor radiotechnicus, 223 voor radiomonteur en 7 voor televisietechnicus, waarvan 8 candidaten zich terugtrokken (6 voor radiotechnicus en 2 voor radiomonteur). Wegens onvoldoend schriftelijk examen werden afgewezen 110 candidaten radiotechnicus, 90 candidaten radiomonteur en 3 candidaten televisie-technicus.

Voor het mondelinge gedeelte werden opgeroepen 63 candidaten radiotechnicus (1 candidaat van vorig examen), 131 candidaten radiomonteur en 4 candidaten televisie-technicus, welke mondelinge examens werden gehouden op 24, 25 Mei, 1, 2, 6, 7, 27, 28 Juni en 6 Juli 1955. Afgewezen werden 24 candidaten radiotechnicus, 47 candidaten radiomonteur en 1 candidaat televisie-technicus.

Geslaagd zijn in totaal 35 candidaten radiotechnicus, 71 candidaten radiomonteur en 3 candidaten televisie-technicus. 4 Candidaten radiotechnicus en 13 candidaten radiomonteur werden voor een herexamen in aanmerking gebracht. Van de 14 candidaten die een herexamen moesten afleggen was 1 candidaat verhinderd. 9 Candidaten radiomonteur en 2 candidaten radiotechnicus slaagden.

Een van de geslaagden voor radiotechnicus, n.l. C. W. H. van Huijstee, Bilthoven, werd bij het Bestuur van het Ned. Radiogenootschap voorgedragen voor toekenning van de examenprijs van het WERA-fonds.

NIEUWE LEDEN

Ir A. C. H. Borsboom, Alexanderlaan 17a, Hilversum.
Ir A. Bijl, Frits Ruysstraat 20B, Rotterdam (O.).
Ir L. Ongkiehong, Lamarckhof 14[1], Amsterdam (O.).
Ir T. Poorter, Pieter Huyssensweg 20, Eindhoven.
Ir G. Radstake, Piet Heinstraat 21, Den Haag.
Dipl. Ing. J. L. Roulet, Hertesprong 18, Eindhoven.
Ir L. G. Wubben, De Bazelstraat 17, Eindhoven.

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Ir J. Davidse, Anna Paulownastraat 1A, Eindhoven.
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Ir G. Franken, Veenendaalkade 104, Den Haag.
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Dr F. L. Stumpers, Pasteurlaan 14, Eindhoven.
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