THE ROLE PLAYED BY THE GANZ FACTORY IN THE EARLY ELECTRIFICATION OF EUROPE AND THE PRESENT ELECTRIFICATION OF THE BALKAN AND LEVANTINE COUNTRIES

The Hidroelectric Power Plant of Ikizdere

It was during the last decades of the 19th century that a world-wide interest in the new source of energy, namely electricity, was first aroused, and this interest has been steadily growing ever since. A bewildering variety of new machines, equipments, structures and instruments has been brought forth with a view to utilizing, "taming" and transforming the new force, *i. e.* electric current. In the course of this process, the dynamo, the telephone, the incandescent lamp were invented ; Déri, Bláthy and Zipernowsky — all three of them engineers of the Ganz Factory — constructed the first transformer ; briefly the new energy — promising a pace of development never dreamed of before — began to conquer the world, and is still steadily gaining ground in the field of telecommunication and machine-tools. Electrical industry is enjoying a miraculous development.

Endeavours to produce electrical energy in the cheapest possible way date from its very birth. It did not take long for attention to be directed towards hydraulic power which was only natural, for this form of energy — supplied gratuitously by nature — had been exploited by mankind since times immemorial. Side by side with the earlier directly-working turbines of fluor mills, paper mills, textile works and other industrial water turbines there appear the first hydroelectric power plants.

Never since having brought out its first water turbine in 1866 has the Ganz Factory ceased to keep abreast with the progress of turbine construction. The initial period is characterized by the manufacture of Jonval turbines, Girard's partial-admission turbines and, as a combination of these two types, the double-crown turbines. Such turbines, as produced by the Ganz Works, had a head up to 100 m and a capacity up to 700 h. p. The appearance of the Francis turbines meant a decisive turn in the process of development. Owing to comparatively high r. p. m. and Fink's method of vane adjustment, this type proved particularly suitable for the driving of electric generators. It was in 1897 that the Ganz Works constructed its first turbine of this type. Francis turbines took a rapid development hereafter and, at the same time, also turbines of the Pelton type began to be increasingly used for the utilization of steeper heads.

As early as 1898 did the Ganz Factory supply the units required for the construction of the hydroelectric plant at Jajce (Bosnia), *i. e.* eight 1000 h. p. and two 632 h. p. Francis turbines with horizontal axles. Turbines made by Ganz could be found almost at every point where electrification had gained ground, and it is not an exaggeration to say that the first really significant European hydroelectric power plants were the products of the Ganz Works. It was likewise in 1898 that Ganz delivered four 1400 h. p. turbines to the power station of the Etschwerke at Bozen-Meran, four 1600 to 1800 h. p. turbines to the power station of Tivoli which supplied the lighting of Rome, while — in 1899 — two 1200 h. p. turbines were manufactured for and delivered to the city of Innsbruck. After this, the old types —

Girard and the double-crown turbines — began to be obsolete, so that, for low and medium heads, nothing (or almost nothing) but Francis turbines had come to be employed : these were single or twin turbines built in open shafts with a spiral waterway, or so-called boiler (twin) turbines. The North Italian plant at Morbegno, erected in 1900, was provided with three such 2000 h. p. Francis turbines.

The four twin spiral Francis turbines, each with an output of 6000 h. p., manufactured for the Dalmatian town of Manoilovac and the two 4000 h. p. turbines made for the Subiaco plant of the city of Rome in 1904, were really outstanding technical achievements at the outset of the present century. In addition to those we have mentioned, the following of the several hundreds of power plants equipped with Francis turbines, deserve to be noted : that of Arci with two 5000 h. p. twin spiral turbines which supply the city of Rome with electric current, further the first construction of the Almissa power plant in Dalmatia (1911) which was provided with two twin spiral turbines of 20 000 h. p. each.

The Pelton turbines, developed along with the Francis type, are likewise significant milestones on the path of progressing electrification in the history of the Ganz Works. Such turbines were made by Ganz for the Italian town of Spoleto in 1896 and then for the town of Foligno : they provided the current necessary for the lighting of these towns. A whole series of Pelton turbines were manufactured for the rolling mill of Kraina-Assling, among them a unit of 1738 h. p. for Jauerburg (head : 320 m). The four twin Pelton turbines of 1500 h. p. each (head : 324 m) delivered to Port Madoc, England, in 1904 merit special mention. The next delivery to England was that of a 3000 h. p. unit in 1907 for the Conway Aluminium Works.

Uncertain as the prospects of turbine production seemed to be in Hungary after World War I, the management of the Ganz Works decided not only to maintain but even to develop the manufacture of water-power machines. In taking this decision, the management was encouraged, partly by the boom which it hoped would arise on account of the expected large-scale post-war constructions of hydroelectric power plants in the Balkan states, and partly by communications and news concerning plans of a large-scale development of irrigation and drainage in Egypt.

We must remember that, as far back as the last decade of the past century, it had become obvious that — reasonably — the manufacture of rotary pumps (performing the inverse of the work done by turbines) should be taken in hand, side by side with the continued production of turbines. It was, thus, at this time that the production of standard pumps, for mines and waterworks in the first place, was begun.

With a view to marketing both kinds of hydraulic machinery the management of the Ganz Works established commercial relations with numerous countries around 1920 : with Roumania, Yugoslavia, Bulgaria, Greece, Turkey, Italy, Spain, Poland, Egypt, India and various South-American countries. Outstanding among supplies made at this time were the construction of a hydroelectric plant at Patras (Greece) in 1924 with 1000 h. p. Francis turbines (head : 115 m), as also two 30 000 h. p. Francis turbines (head : 109 m) for the completion of the above-mentioned power plant of Almissa. No small credit may be derived from the fact that the turbines of the Almissa plant are still in full service and have never ceased to perform their work, without any general overhaul, to the complete satisfaction of the Dalmatian plant management.

As proved by orders received and deliveries effected, between the two world wars, and after World War II, the Ganz Factory has always kept pace with the development of water turbines.

It was especially the general industrial prosperity ensuing after the second world war which set significant new tasks to those engaged in the production of water-power machines. Expanding industrialization requires more and more energy supply and gives rise to the erection of a steadily increasing number of hydro electric plants. The management of the Ganz works was well prepared for this onrush and is now in a position to manufacture most up-to-date equipments which are capable of satisfying all reasonable requirements.

All water-power plants, as also many of the larger pumping stations made by Ganz during the last decades, were completely automatized. Some of them do not require any operating crews and can be controlled from a distant power plant. The latest products are automatized to such an extent as to need only the pressing of a button for all necessary operations, including start and stoppage, to be performed, and it is only the load changes which have to be regulated from the control room. Noteworthy results have been achieved by the Ganz Works also in the development of speed-regulators.

Since the termination of World War II, the Ganz Works has not only been able to meet Hungary's own demand of hydraulic machines but has also built up a considerable export market for its products in Roumania, Bulgaria, Poland, the Soviet Union, Turkey, India, Egypt, China and Yugoslavia.

A new type of turbines, the "Ganz-Mignon" micro turbine, united with a generator and provided with a speed governor and voltage adjuster, was designed during the last years and is now manufactured in series. The whole structure constitutes a complete unit, its assembly and manipulation are quite simple, and is eminently suitable for the generation of current required by smaller communities, settlements and farms.

Traditions almost a century old, together with theoretical and practical experiences, justify the claim of the Ganz Works to be ranked with the world's most prominent manufacturers of water-power structures.

It was a few years ago that the Iller Bankasi (an investment bank in Turkey) invited tenders for the construction of a hydroelectric power plant, that of Ikizdere. Among other tenders the most favourable and most complete was that submitted by Ganz which, on account of its undertaking to construct and erect both the electric and hydraulic equipments, succeeded in obtaining the indent.

"Ikizdere" means "twin brooks": the name of this river derives from the fact that it arises from the confluence of two equal branches. Strictly speaking, not just a single power plant but a whole system is being built at and in connection with Ikizdere, a place removed some 40 kilometres from the seashore. Situated in the northeastern corner of Turkey, this area in Asia Minor is flanked on two sides by the Soviet Union and the Black Sea, respectively. Supplying this region with electric current, the newly established system will satisfy an important requirement of cultural development in this part of the country. In addition to Ikizdere itself the said system embraces four littoral townships and their environments. The establishment in question must be regarded as a very significant one, and its importance is the more considerable, as no similar energy-supplying system can be found within a radius of 500 kilometres.

The technical task involved merits special mention. The water of the river, for instance, is conducted to the plant in two sections through a tunnel which, blasted in the granite rock, has a length of 3½ kilometres. Arrived at the plant, it is by means of a steel pressure tube of 300 m length and 2 m diameter that the water is dashed upon the turbine.

The most important part of the machinery is a hydroelectric equipment consisting of three units. The water turbines are of the Francis type, with vertical axles and scroll cases which, utilizing a net head of 160 m, consume 4 m^3 per second of water and have, each, an output of 7500 h. p. with 750 r. p. m. Highest efficiency: 89 per cent. A likewise vertically-axled three-phase synchronizing generator is directly coupled with the turbine. Technical data of the generator: 6500 kVA permanent output; 6300 V voltage; 50$\sim$; 96% efficiency.

Regulation in accordance with varying operative conditions is effected by means of an automatic, oil-pressure speed-regulator, system Ganz. A constituent part of the hydraulic equipment is a spherical valve before the turbine : it has a diameter of 1000 mm and is likewise automatically governed by oil pressure.

The electrical outfit includes the complete equipment and the instruments of the engine room, the transformer station and the switchgear in the open air, the transmission line and the substations. The current generated by the power plant is to be conducted by a 40 km long line to Iyidere on the seashore, therefrom to the town of Rize eastwards along the coast, as also to Arakli and Trabzon (and its surroundings), towns to the west. A step-down transformer station will be erected in each of these towns.

The entire hydraulic and electric outfit of the power plant, including substations and transmission lines, is manufactured in and is to be shipped from Hungary.

The construction at issue is a striking proof of the fact that, true to its traditions the Ganz Works has succeeded in maintaining the good quality of its products, is capable of speedy performance, and is not inferior to even the most renowned and most prominent manufacturing establishments of the world.

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THE EFFECT OF NOISE SOURCES ON THE PERFORMANCE OF A MULTI-CHANNEL FM RADIO LINK

By

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Introduction

Microwave radio relay lines are designed with a most particular view to the fidelity of the signal transmission between the input and the output of the system. One of the most important characteristics of a multi-channel telephone system operated on a radio link is the total noise power appearing within one channel in the output signal. The length of the radio relay line is limited by the highest noise power which can be allowed in a telephone channel. Disturbances affecting multi-channel transmission are of "noise" character and can be divided, with a view to their origin, into three fundamentally different groups

a) thermal noise,

b) intermodulation between speech channels,

c) interference due to external sources.

It can be shown that FM-systems are affected by two prevailing types of intermodulation. These are the non-linear amplitude/frequency-deviation characteristic and the fluctuations of the group delay time. A characteristic feature of FM-systems consists in the fact that no distortion is caused by non-linear characteristics of tubes or non-uniform frequency response of the amplifiers. On the other hand, non-linear phase characteristics of the amplifiers, reflections in the antenna feed line and multi-path signal propagation cause time-delay distortions which may become critical if a number of relay stations is inserted.

Multi-channel telephone systems, to eliminate disturbances due to intermodulation, have to comply with high linearity requirements. However, phase variations within the relatively narrow band of the individual speech channels can be tolerated.

Sources of intermodulation noise

The most important non-linear distortions encountered in FDM—FM multi-channel systems can be classified, with respect to their origin, as follows:

1. Distortion of the basic-band equipment due to non-linear characteristics of the amplifiers.

2. Distortion of the modem equipment due to its non-linear amplitude and phase characteristics.

3. Distortions of the high-frequency transmission path, which are

a) distortions due to the finite band width,

b) non-linear IF and RF phase characteristics,

c) reflections in the antenna feed line,

d) selective fading.

With FM signal transmission two large groups of non-linear distortions can be distinguished, *i. e.* the static and dynamic distortions. Coefficients of static distortions are independent of the modulating frequency, while those of dynamic distortions increase with the same.

Addition of intermodulation noises and their distribution along the hypothetical reference circuit

When considering addition problems of intermodulation noise powers it is advisable to separate the examination of the problem of addition between modem sections from that within a single modem section, because between the modem sections the phase characteristic in the basic band is a prevailing factor. Noises due to crosstalk between modem sections can be assumed to have a power-summation law, the phases of the basis-band singals being related at random.

Within a single modem section crosstalk disturbances due to amplitude and phase distortions are power-additive. Within one station the different sources of intermodulation noise can be considered as independent and for this reason, as a first approximation, an addition of the distortions due to different sources can be assumed.

If considering the result of non-linear products of identical type produced within the same modem section no simple law of addition can be found.

When designing for optimum frequency deviation the thermal noise and the intermodulation noise are equal. Actually, the intermodulation noise increases with the frequency deviation, while the thermal noise decreases. Accordingly, the total psophometric noise in the output signal of the hypothetical reference circuit can be distributed as follows :

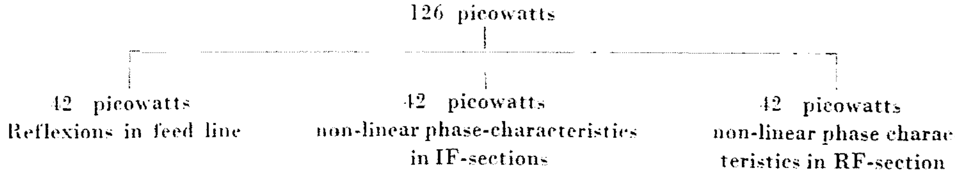
- 10 000 picowatts Total noise
  - 250 picowatts Noise of the basic-band equipment
  - 7500 picowatts High-frequency circuit noise
    - 3750 picowatts Ground noise
    - 3750 picowatts Intermodulation noise

The ground noise is composed of thermal noise and radio frequency interferences including a fading reserve of 5 decibels. Intermodulation noise power is to be determined by psophometric measurement over a band width of 3,1 kc/s. With the allowable intermodulation noise power distributed among the nine modem sections, the noise power which may be generated within a single modem section is 420 picowatts. The following calculations will be based on unweighted noise over a band-width of 4 kc/s and, to compensate for this, the admitted level of the intermodulation noise power will be increased by about 3 decibels to 840 pW. One quarter of this noise power will be assigned to the modem equipment and three quarters to five transmitters and receivers. In this way the admissible noise power attributed to one modem equipment is 210 picowatts which is divided as follows :

- 210 picowatts
  - 105 picowatts amplitude nonlinearity
    - 52,5 picowatts modulator
    - 52,5 picowatts demodulator
  - 105 picowatts phase nonlinearity
    - 52,5 picowatts modulator
    - 52,2 picowatts demodulator

According to the above distribution plan one half of the noise power should be due to amplitude distortion and the other half to phase distortion. Modulator and demodulator are supposed to have equal shares in these distortions.

With the 630 picowatts, calculates for the five transmitter-receiver pairs, the noise power which can be due to each pair is 126 picowatts. As a first approximation, this noise power should be divided equally among the noises caused by feed line reflexions, non-linear IF-phase-characteristics and non-linear RF-phase-characteristics :



Distortions due to non-linear phase characteristics in RF-sections include the phase distortions of the RF-filters and the disturbing phase modulation due to amplitude modulation in the travelling-wave tube.

Relation between electrical characteristics and limit values of noise power

When examining the effect of different noise sources on the transmission characteristics of the system, a method of measurement should be assigned to each source of noise. Amplitude nonlinearity are characterized by harmonic distortion measurements, phase nonlinearity by measuring the fluctuation of the IF and RF time-delay, and the reflexions in the transmission line by standing wave ratio measurements. In addition, a measurement indicating the amount of phase distortion caused by AM-signal amplification in the travelling wave tube is also required.

Noises due to the non-linear amplitude characteristics are interrelated with measured value of linearity through the distortion coefficient. With quadratic characteristics supposed as first approximation the following relation can be established between the noise power and the inverse of the distortion factor:

$$\left(\frac{F}{H_2}\right)_q = \frac{4\,P^2}{d_2\,N_q}$$

where

F is the amplitude of the test signal,
H_2 is the amplitude of the second harmonic,
P is the total power of the channels,
d_2 is the noise power of the second order products within a band width of 4 kc/s,
N is the number of channels and
q is the power of the test signal referred to 1 milliwatt.

The intermodulation noise power within one channel is proportional to the total harmonic power, to the density function of the second-order products, and to the ratio of the band widths.

The amplitude-density function determines the noise power within 1 c/s bandwidth. Harmonic distortion and linearity are interrelated, in case of quadratic characteristics, by the following equation:

$$K_2\,\% = \frac{(1-m)^2}{4\,(m^2-1)}\,100$$

where

K_2 is the coefficient of the second order harmonic and
m is the linearity defined by the formula

$$m = \frac{g_{min}}{g_{max}}$$

where g_m is the mutual conductance.

With quadratic characteristics assumed, there is a difference of about one order between distortion coefficient and linearity.

Noises due to non-linear phase characteristics are interrelated with the fluctuation of the group delay time by the following equations obtained by considerations similar to those applied above.

$$\left(\frac{F}{H_2}\right)_i = \frac{1}{2}\,\frac{P^2}{d_2\,N_q}$$

In this equation the limit value of the harmonic distortion is expressed as a function of the drive and of the noise tolerated within one channel. Between the fluctuation of the time-delay and the limit value of the harmonic distortion the following equation holds:

$$\frac{\tau_2}{B/2} = \frac{2}{\omega\Delta\omega\,\frac{F}{H_2}}\,.$$

where

τ_2 is the fluctuation of the delay time,
B is the IF band width,
ω is the frequency of the channel under consideration and
$\Delta\omega$ is the frequency deviation.

Since regarding noise problems the highest channel is operated under the most unfavourable conditions, ω is the highest channel frequency.

The reflection in the feed line and the noise power caused by the same are related in case of a long feed line by the following equation :

$$d_2 = \frac{u^2}{1} \left(\frac{f}{\Delta f}\right)^2 \frac{P}{N} \Phi(\tau, \Delta\omega)$$

where

u is the amplitude of the reflected wave,
f is the frequency of the channel under consideration,
τ is the delay time of the one-way feed line,
Δf is the peak frequency deviation and
Φ is the echo-distortion function.

The dependance on delay time τ and peak deviation Δf can be given graphically.

Using the above relations noise powers can be computed from the results obtained by measuring the non-linear properties of the amplitude and phase characteristics, and can be compared to the admissible values. It should be noted, however, that results obtained by linearity measurement calculations based on the same are only of informatory character. Intermodulation noises are determined by a special measurements : The telephone channels are replaced by a continuous noise spectrum of appropriate band width. The band corresponding to the channel under test is cut out from the noise spectrum, and the noise power measured within this band is characteristic to the intermodulation distortion of the system.

The results of the measurements may have great influence to the rearrangement of the planned distribution of the admissible noise power. The final distribution will greatly depend on realization possibilities of the different components. Some types of modulator circuits, for instance, may cause distortions far below the admissible value. The noise power saved in this way can be used to reduce requirements to be put to components in which the compensation of noise is involved with more difficulties.

The C. C. I. T. T. recommendations concerning the hypothetical reference circuit constitute very high requirements regarding different sources of noise.

Results of computations using the above relations and made for a 600-channel system show that in a band width of ±10 Mc/s the admissible value of the delay time fluctuation is 1 nanosecond and that of the amplitude fluctuation 0.1 decibel ; the reflection caused by the feed line should be less than 1.05. The most considerable one of the RF-noises is the distant-field interference arising from the back radiation of the antenna. From this point of view, the optimum value corresponding to about 65 decibles can be obtained by the hog-horn type radiator. Noises due to this radiation can be compensated only by improving the signal to thermal noise ratio. for the low value of the admissible intermodulation noise results in extremely high requirements concerning each component part of the system. If the number of the channels to be transmitted by the system is raised above 600, the requirements outlined above are to be satisfied with a broader band width and with a higher drive. Owing to this fact the requirements concerning the individual components of the system are still higher.

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