INDUSTRIAL REVIEW — AUS DER INDUSTRIE

ENDLESS ROPE HAULAGE WITH "OHNESORGE" STRESS ADEQUATOR

By

W. Meinhardt

Certificated mining Engineer, emeritus professor of the University of Sopron, Hungary

Since the last two or three decades haulage by small narrow gauge locomotives became a strong competitive factor with the endless rope haulage, which was ever increasingly gaining ground up to that time. Locomotives may be in some cases undoubtedly even more advantageous, still in general their relative rapid expansion is not always justified.

Before proceeding to discuss more closely the Ohnesorge equipment, chosen for subject in the present paper, which is one of the most important systems in the endless rope haulage and a device playing a decisive role in it, it seems advisable to examine nearer these two kinds of light railway haulage systems, confronting their advantages and drawbacks to make ourselves able in a given occasion to take objective decisions as to which of the two systems should be adopted.

The two systems are in keeping one with the other in the fact that in tubs of small load capacity (0,5 to 1,0 ton) relatively large quantities may be hauled cheaply and safely, but to distances not excessively long by their means, on a narrow gauge track, respectively in case of the endless rope haulage equipment also on suspended track or aerial ropeway.

There are, however, many important differences between the two systems as well, namely, to mention only the more significants:

1. Locomotives can be employed only on horizontal or nearly horizontal tracks, with max 30 per mille incline, while endless rope haulage can work also on considerably sloping tracks, up to an incline of even 300 per mille, while the load can be hauled both downwards or upwards. The great advantage of the latter can come to full effect in the mining particularly, when the turn comes to haulage of large volumes, not only in tunnels, pits, underground main haulage ways, but also in inclines and drifts with a considerable slope of 100 to 300 per mille.

2. With the endless rope haulage — in case of sloping tracks — the haulage of cars proceeding upwards on the other track, or in case of suspended ropeway, on the other rope, is assisted by the component of the weight of empty tubs (Ge) showing the direction of the slope, deducted from it the friction force caused by the vehicle and railtrack, i. e. the

$$G_e \cdot \sin a - \mu \cdot G_e \cdot \cos a \text{ value*}$$

which means a saving of energy. On the other hand, when the full tubs are proceeding downwards on the slope, the braking power necessary for the speed regulation is reduced by the empty ones. In case of haulage by locomotives such a balancing advantage cannot arise.

3. According to some opinions higher outputs can be secured with haulage by small locomotives. In general this view is not sound at all. The conditions for a high output of locomotive-haulage are anyhow: the longest possible train and the highest possible tractive speed. These require before all a locomotive of large adhesive weight. As the weight of the rails per running metre to be built in into the track is governed by the axle load of the locomotive, it exceeds at least by 4 to 6 kg the weight of the rails used in the ropeway. Namely, in the latter case the rail is charged only by the axle load resulting from the weight of the loaded tub and from the weight of the about 20 to 30 m long hauling rope between and connecting each two tubs, which usually amounts to hardly one third of the locomotive's axle load.

When chosing the rail section, we are taking here rather the wear into consideration and consequently usually chose a stronger section,

* where
G_e = weight of empty tubs running on a sloping track
a = angle of incline of the track
μ = coefficient of all frictions connected with the running of the tubs.

than required by the axle load and thus a rail-weight will result, which is still by 4 to 6 kg less than the weight of rails built-in under the locomotive.

To obtain high outputs in case of locomotive haulage we are forming trains consisting of 100 tubs. Such trains require passing tracks, respectively transport rails or stations of 280 to 320 m length in addition the formation of triple tracks on both ends of the tracks. Difficulties are frequently caused even on the surface by the space required for station of the locomotive haulage. In case of underground haulage these difficulties are more significant, since the building of stations in this case means considerable additional costs of investment, as far as a wider mine-area is required for the triple track and the larger width involves an increased section height. The expenses of the corresponding constructions exceed by about 70 to 85 per cent the building costs of the double line terminuses necessary for the endless rope haulage.

For endless rope haulage a double line is indispensable on the whole length of the track. For locomotive haulage when passing rails of adequate number and length are interposed, the other part of the track may have a single line, but also in case of locomotive haulage large outputs cannot be obtained undisturbed, unless the tracks are built with double lines throughout.

In underground haulage only the forepart of the train is brought near to the shaft or on the surface haulage to the place of discharging or utilization. The last tub of the train remains at a distance of about 200 m and this one as well as all those which stop farther off from the shaft, etc., must be brought forward either by hand power or by some expensive mechanical shunting equipment serving specially for this purpose. Against this with rope haulage all the tubs are brought quite near to the shaft. In case of locomotive haulage the train must be braked if the slope of the track exceeds 3 per mille. The operating of tubs with brakes is in the practice not only expensive, but involves many difficulties as well. The purchase cost of tubs with brakes is higher by 30 to 35 per cent and the wages of the brakeman mean equally a considerable increase in the operating expenses. All these difficulties and additional costs are absent in the endless rope haulage, since each tub is coupled separately to the hauling rope and this fact alone makes their escape impossible.

In the examination of the capacity we take as a basis a three km long underground horizontal haulage track connecting the pit bottom with the loading station at the inner end of the main hauling way. Detailed calculations lead to the results in Table 1.

Double output cannot be attained by putting two locomotives in service, because even with the most careful schedules and time tables the locomotives will invariably interfere with one another in their runs to some extent. Neither in wirerope hauling can a double output be attained through the coupling of two mine cars, because in this case more time (instead of 20 sec about 25 to 26 sec) must be devoted — for reasons of safety — to the coupling and uncoupling of tubs to and from the rope. On the other hand in case of wire rope — or suspended rail haulage — the buckets are without any manual intervention attached to the hauling rope by an automatic coupling device, working with perfect safety. This enables to reduce the coupling time to ten seconds, resulting in the increase of the output to 360 cars per hour and this under whatever conditions of sloping.

So, on a horizontal, adhesive track with good organization a bigger but at least the same output can be achieved by means of

Table 1

Capacity per hour

Locomotive haulage		Endless rope haulage	
the train is composed of 100 tubs max speed: 15 km/hour average speed: 12 km/hour		in case the tubs are coupled	
		singly	two by two
		time of coupling	
with one locomotive	with two locomotives	20 sec	26 sec
		Speed: lm/sec	
150 tubs	255 tubs	180 tubs	275 tubs

the endless rope haulage and in case of the incline exceeding 3/mille the manpower required will be considerably less than for locomotive haulage.

No remarkable difference exist between the energy requirement and other operating cost of the haulage systems, however, detailed calculations usually decide this question rather in favour of the endless rope haulage. On the whole the factor of the output and the possibility of application from the viewpoint of incline, reliability of service and expenses of investment all argue in favour of the endless rope haulage. Against all this the locomotive haulage offers, however, the important advantage that it can be well applied on meandering tracks too, while the endless rope haulage can come into consideration only on tracks absolutely straight or in case of one or two brake points only. This latter requirement is of such a nature that in the protect work of a gallery or surface track it may be either realizable or not. In final issue the following conclusions may be drawn from the above-said:

1. On meandering tracks only locomotive haulage can be taken into consideration;
2. On absolutely straight tracks the priority is due in many cases to the endless rope haulage but this so only since the technical difficulties presenting themselves in this haulage system on account of its special nature are perfectly resolved. Until this has been achieved it was justified to give the preference to locomotive haulage, when large haulage outputs were concerned, as the above-indicated technical difficulties, appearing in case of the endless rope haulage — which will be discussed later at length — are turning up when large hauling outputs are in question. These difficulties are caused by the tensions appearing in the various sections of the hauling rope and in values different from one another. The tension differents are able to hurt the driving pullies, the hauling rope and the whole gear unless provisions are made for their equalization. By means of the friction arising between the haulage rope and the groove-lining of the pulley the hauling rope laid on the driving pulley must be laid to run at a speed perfectly identical with the peripheral speed of the driving pulley, to avoid the rope-slipping in the grove of the pulley and to prevent thus the excessive wear of the groove-lining and ropes.

The mathematical relationship between the rope-tension appearing in the strand running up to the rope pulley and in the strand running down from it is expressed by the well-known formula:

$$S_1 = S_2 \cdot e^{\mu\alpha}$$

while the power transmissible by means of the gear is given from the

$$P = S_1 - S_2 = S_2\,(e^{\mu\alpha} - 1)$$

relationship. Thus, the transmissible power depends only on the S_2 pull power in the running off strand, on the friction coefficient and on the value (α) embraced by the rope. Owing to the given conditions of the materials to be employed (wire rope and pulley-groove lining) the friction coefficient is liable to change only to a limited extent by chosing the different wood and leather-materials used for the pulley-lining. Regarding the friction coefficient the data in Table 2 were supplied by a large number of experiments.

This means that the value of μ is varying within wide ranges. For the sake of precaution it is usual to calculate with $\mu = 0.15$—0.20 value when oak or hornbeam and 0.20 value if elm is employed. The considerable increasing of the power to be transmitted with the driving pulley can be obtained the most reliably by increasing the α-wrap. For this purpose two driving pulleys are employed instead of one and they are wrapped in S form by the rope. The nearer are the driving pulleys to one another, the bigger is the warp. The detailed data are supplied by Table 3 and Fig. 1:

In view of the importance of the angle of lap it is desirable to bring the pulleys as

Table 2

Value of μ, if the						
condition of		material of the pulley lining is				
the rope	the pulley	oak	poplar	hornbeam	elm	leather
dry........	dry	0.5—0.7	0.8	0.7—1.0	—	0.18
greasy	damp	0.21	0.3	0.15	0.20	0.16
very greasy	dry	0.15	0.18	0.12	—	0.125

Table 3

Wrap of the driving rope in degrees and π in case of two driving pulleys, in function of the axle bases.

Axle-base of pulley expressed through pulley radius	Angle of lap on each pulley		Angle of lap on two pulleys in total	
	in degrees	in π	in degrees	in π
2.5 r	233° 08′	1.294	466° 16′	2.588
3 r	221° 45′	1.232	443° 30′	2.464
4 r	210° —	1.166	420° —	2.332
6 r	199° 27′	1.107	398° 54′	2.214
8 r	194° 28′	1.080	388° 56′	2.160

Correlation of disc-distance and angle of lap

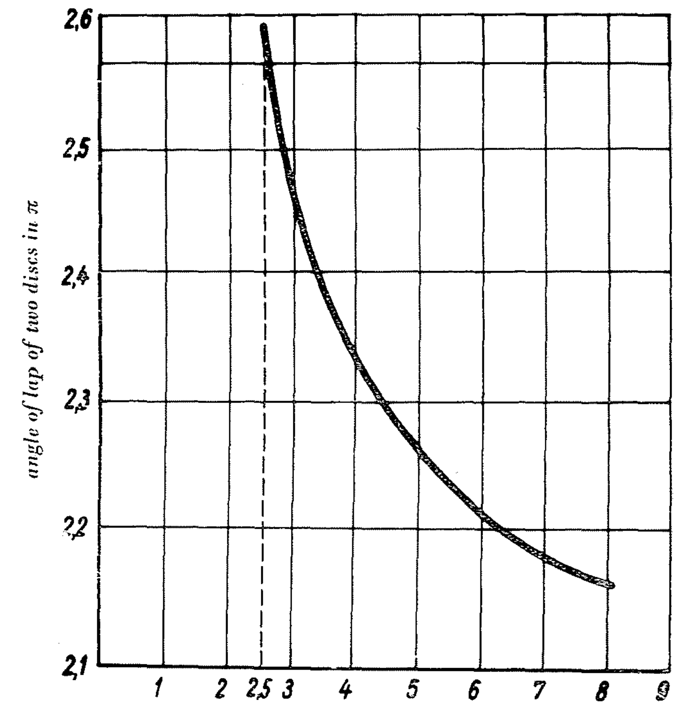


Fig. 1

near as possible to each other. However, for constructional reasons, the distance cannot be less than 2.5 r. since the pulleys are cast-in one with their somewhat larger toothed wheel and between them are located also the small gears driving them. The distance between the drive pulleys of the Ohnesorge endless rope haulage equipment of 1800 diameter mm manufactured by the Duclos Mining Machine Works is 2700 mm, i. e. 3 r, thus the wrap equals to 2,464 π.

The highest tension appears in the rope strand winding onto the first pulley. The rope-strand running down from it is at the same time the rope-part winding onto the second pulley, so the pull force appearing in the rope-strand running down from the first pulley is the same as the tensile stress of the rope-part winding onto the second pulley. The stretching of the rope-strand is proportional with the latter i. e. with the tensile stress, which consequently will be larger in the running up, than in the running down rope-strand, thus in final issue the lengths of the rolling up and running down rope-strands will be different. The difference in length is equalized on the periphery of the pulley in form of slippage, which causes the wear of the rope and pulley lining and the latter results, already within a short time, in the decrease of the diameter of the pulley frequently even to the extent of 20 to 30 mm.

The wear of the pulley lining is strongly influenced further by the pressure acting on the periphery. Due to this, the lining of the first driving pulley is wearing out more intensely, because it is here that the largest pull force appears, thus the pressure acting on the periphery unit will be equally the highest here. As a result of all these the difference in the diameter of the rope-pulleys will be evident already within a relatively short time. If now the number of revolutions of the pulleys remains unchanged, the rope on the pulley will be forced to slip. This momentary slippage will be ever more frequent, repeating itself nearly periodically. If we wish to avoid the occurrence of such a violent and frequent equalization of the supertension, the two driving pulleys must not run at an unvariable revolution-number which on the other hand will always exist in case of a rigid-geared transmission. This problem being decisively delicate for any endless rope haulage is completely resolved by the Ohnesorge tension equalizer, which — employing a *single driving motor* — makes the revolution-number of the pulleys independent from each other, so that in final result they will always most accurately adapt themselves to the actual length of the rope-strands rolling up and down. Hereby the rope-slippage and the wear of the rope pulley-lining, which accompanies it, will cease at once, the whole haulage equipment will work in a shake-proof manner, the service time of every part of it will be lengthened, the motor load will be constant, the energy-consumption will decrease and in consequence of all these the endless rope haulage will be entirely freed of the technical difficulties experienced so far and becomes a completely irreproachable means of haulage for the performance of high outputs.

Though the groove-lining of the pulley will still continue to wear it will depend only on the pressure acting on the periphery. The Duclos Mining Machine Works were induced precisely by this fact to manufacture, besides equipments with 1100 and 1400 mm pulley diameter destined for small outputs, with 1800 and 1400 mm pulley diameter as well, for the case of higher output, which requires a higher pulling force. Moreover, for quite special load- and output requirements haulage is recently designed 3000 mm pulley diameter, naturally with the application of the Ohnesorge tension equalizer.

From Fig. 2 title "GEAR" it may be understood, how the revolution-numbers of the driving pulleys are made independent from each other by this device. By intermediation of the elastic "C" shaft coupling, shaped also as a brake-support the slip ring asynchronous motor (M) drives the "I" shaft of the reducing gears accomodated in the closed "G" cast iron casing. No 1 spur wheel joining the No 2 spur wheel is wedged on it. The latter wheel is wedged on the II shaft on which also the No 3 spur wheel is wedged. This is joined by the No 4 large spur wheel, between the spokes of which the essence of the whole device: the planet gear is built-in. Its small bevel gears No 11 transmit half of the moment to each of the large bevel gears No 12_5 and and 12_9 meshing with them. One part of the moment arrives with unchanged value from No 12_9 bevel gear on No 9 bevel gear seated with it on the common "III" shaft, wherefrom the moment is transmitted by the No 10 large bevel gear on the No 13 working pulley assembled with it.

The other part of the moment is transmitted unchanged by the No 12_5 large bevel gear to the No 5 bevel gear seated together with it on the same "IV" tubular shaft, wherefrom it gets on the No 6 spur wheel and from there on the No 7 small spur wheel wedged on the same "V" shaft. No 7 is meshing with No 8 large toothed wheel, while the latter is assembled with No 14 working pulley. The revolution of the two driving pulleys are independent one from the other, which is caused by the fact that the 12_9 large spur wheel driven by the No 11 small planet wheel is wedged on the "III" shaft, while the 12_5 large spur wheel is wedged on the "IV" tubular shaft, independent from the "III" shaft. Thus these two shafts transmit the moments separately to the driving pulleys, on each of which exactly the same rope-length can be wound, even when due to wear a change has occurred in the pulley diameter as their r. p. m. is able to follow the movement of the rope and actually follows it.

After these questions let us now examine the moment-conditions of an endless rope haulage equipment, with a given 1800 mm

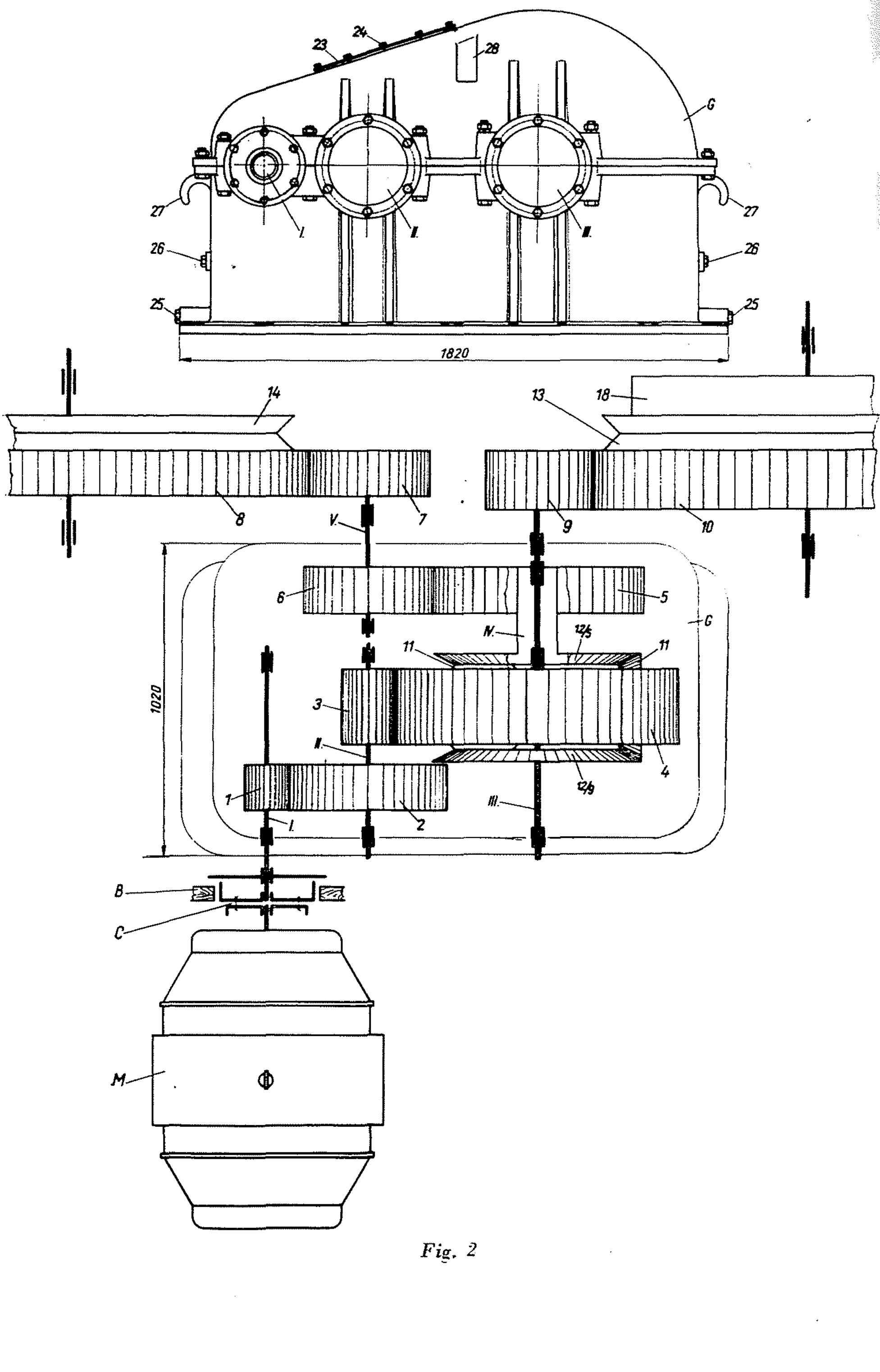

23
24
28
G
27
27
I.
II.
III.
26
26
25
25
1820
14
13
18
8
7
V.
9
10
6
5
IV.
12/5
G
11
11
3
II.
4
12/9
1
2
I.
III.
1020
B
C
M

Fig. 2

pulley diameter, the output of its motors and problems of safety against slippage,

The indexes of the quantities occurring in the calculations such as tooth number, revolution number of the toothed wheels, moments, modifications, etc., refer always to the relative toothed wheel, respectively in case of a double index to the relative pair of toothed wheels. Therefore

z_1 = tooth number of the gear No 1
M_3 = the moment on the gear No 3
$n_{6\cdot 7}$ = means the common revolutions number of the toothed wheels No 6 and 7 and so on. In the machine in question:

the *tooth-numbers* are

$z_1 = 24$	$z_7 = 22$
$z_2 = 85$	$z_8 = 122$
$z_3 = 23$	$z_9 = 17$
$z_4 = 117$	$z_{10} = 108$
$z_5 = 67$	$z_{11} = 24$
$z_6 = 45$	$z_{12} = 54$

Efficiency of the toothed wheels. While deciding about these it should be taken into account that gears No 1 to 6 are lubricated in closed casing with oil bath, while the gears No 7 to 10 are located outside the casing and are lubricated with greasing, which is somewhat less efficient than the oil bath. Accordingly, the toothed wheel efficiencies are the following:

$\eta\, 1.2 = 0.96$	$\eta\, 7.8 = 0{,}94$
$\eta\, 3.4 = 0.96$	$\eta\, 9.10 = 0.94$
$\eta\, 5.6 = 0.96$	

Reduction ratios

$$i_{1.2} = \frac{z_2}{z_1} = \frac{85}{24} = 3.54$$

$$i_{3,4} = \frac{z_4}{z_3} = \frac{117}{23} = 5.1$$

$$i_{5,6} = \frac{z_5}{z_6} = \frac{67}{45} = 1.49$$

$$i_{7,8} = \frac{z_8}{z_7} = \frac{122}{22} = 5.55$$

$$i_{9,10} = \frac{z_{10}}{z_9} = \frac{108}{17} = 6.35$$

$$i_{11,12} = \frac{z_{12}}{11} = \frac{54}{24} = 2{,}25$$

Revolutions

In this calculation we have to take as a basis the existing rope speed, or the peripheral speed of the driving pulleys, which is equal to the rope speed and from here we proceed backwards to the driving motor. The required rope speed:

$$v = 1\ m/sec$$

So:

$$n_8 = n_{10} = \frac{60.100.v}{D\pi} = \frac{60.100.1.0}{180.3.14} = 10.6 \text{ revolution/minute}$$

$$n_9 = i_{9,10} n_{10} = 6.35 \times 10.6 \qquad = 67.3 \quad \text{"} \quad \text{"}$$

$$n_{6\cdot 7} = i_{7,8} \cdot n_8 = 5.55 \times 10.6 \qquad = 58.8 \quad \text{"} \quad \text{"}$$

$$n_5 = \frac{n_{6,7}}{i_{5,6}} = \frac{58.8}{1.49} = \qquad = 39.5 \quad \text{"} \quad \text{"}$$

$$n_4 = \frac{n_5 + n_9}{2} = \frac{39.5 + 67.3}{2} \qquad = 53.4 \quad \text{"} \quad \text{"}$$

$$n_{2,3} = i_{3,4} \times n_4 = 5.1 \times 53.4 \qquad = 272 \quad \text{"} \quad \text{"}$$

$$n_1 = i_{1,2} \times n_{2,3} = 3.54 \times 272 \qquad = 965 \quad \text{"} \quad \text{"}$$

Due to the direct joint the r. p. m. of toothed wheel No 1 is the same as that of the motor and 965 agrees well with the $n_m = 950$ to 970 r. p. m. of the employed 6 pole asynchronous motor.

The moments

M_1 = moment of the driving motor

$M_2 = i_{1\cdot 2} \times \eta_{1,2} \times M_1 = 3.54 \times 0.96 \times M_1 = 3.4\ M_1$

$M_3 = M_2 \qquad 3.4\ M_1$

$M_4 = i_{3\cdot4} \times \eta_{3\cdot4} \times M_3 = 5.1 \times 0.96 \times 3.4 = 16.6\ M_1$

$$M_5 = M_9 = \frac{M_4}{2} = \frac{16.6 \times M_1}{2} = \qquad 8.3\ M_1$$

$$M_6 = \frac{1}{i_{5\cdot6}} \times x\ \mu_{5\cdot6} \times M_5 = \frac{1}{1.49} \times$$

$$\times\ 0.96 \times 8.3\ M_1 = \qquad 5.35\ M_1$$

$M_7 = M_6 = \qquad 5.35\ M_1$

$M_8 = i_{7\cdot8} \times \eta_{7\cdot8} \times M_7 = 5.55 \times 0.94 \times 5.35\ M_1 = \qquad 27.85\ M_1$

$M_9 = M_5 = \qquad 8.3\ M_1$

$M_{10} = i_{9\cdot10} \times \eta_{9\cdot10} \times M_9 = 6.35 \times 0.94 \times 8.3\ M_1 = \qquad 49.5\ M_1$

The full moment :

$M = M_{10} + M_8 = 49.5\ M_1 + 27\ 85\ M_1 = \qquad 77.35\ M_1$

On the other hand, the full moment can be calculated as the product of the pulley radius and the required maximum hauling power.

In our case taking into consideration the slope conditions, track-length, gross and net tub weight, number of mine cars to be pulled simultaneously, etc. the necessary hauling power is equal to $T = 4800$ kg. Thus:

$$M = \frac{D}{2} \times T = 0.9 \times 4.800 =$$

$$= 4.320\text{mkg} = \qquad 432.000\text{cmkg}$$

and here from

$$M_1 = \frac{M}{77.35} = \frac{4320}{77.35} = 56\ \text{mkg} = \qquad 5.600\text{cmkg}$$

Now knowing M_1 numerically already all the other moments can be computed on the basis of the above relationship:

$M_2 = 3.4\ M_1 = 3.4 \times 5.600 = 19\ 000$ cmkg

$M_3 = M_2 = \qquad 19\ 000$ cmkg

$M_4 = 16.6 \times M_1 = 16.6 \times 5.600 = \qquad 93\ 000$ cmkg

$M_5 = 8.3 \times M_1 = 8.3 \times 5.600 = \qquad 46\ 500$ cmkg

$M_6 = 5.35 \times M_1 = 5.35 \times 5.600 = \qquad 30\ 000$ cmkg

$M_7 = M_6 = \qquad 30\ 000$ cmkg

$M_8 = 27.85 \times M_1 = 27.85 \times 5.600 = \qquad 156\ 000$ cmkg

$M_9 = M_5 = \qquad 46\ 500$ cmkg

$M_{10} = 49.5 \times M_1 = 49.5 \times 5.600 \qquad 277\ 000$ cmkg

Knowing the moment values and the revolutions the gears can be dimensioned and the motor capacities computed.

The latters will take the following shape:

Motor outputs :

$$P = \frac{M \cdot \omega}{75} = \frac{M}{75} \times \frac{2\pi}{60} \times n =$$

$$= \frac{M \cdot n}{716}\ \text{mkg}$$

if $v = 1.0$ m/sec speed, $M_1 = 56$ mkg, $n_1 = 965$ r. p. m.

and thus:

$$P_1 = \frac{56 \times 965}{716} = 75.5\ \text{HP}$$

if $v = 0.75$ m/sec speed: $M_1 = 56$ mkg, $n_{0\cdot75} = 725$ r. p. m.

and

$$P_2 = \frac{56 \times 725}{716} = 56.7\ \text{HP}$$

Examination of the security against slippage

In the rope strand running up on pulley I the rope tension: T_f

In the rope strand running down from pulley I the rope tension: T_k

but $T_f - T_k = T_{10}$ and $T_f = T_{10} + T_k$, while at the same $(T_f - T_k) \times R = T_{10} \times R = M_{10}$

In the strand running up on the II pulley the rope tension is the same as the rope tension appearing in the strand running down from the I. pulley, i. e.$= T_k$

In the strand running down for the II. pulley the rope tension $= T_1 \cdot$ But $T_k - T_1 = T_8$ and herefrom $T_1 = T_k - T_8$, while at the same time $(T_k - T_1) \times R = T_8 \times R = M_8$.

In the rope strands running up and down it is reasonable to chose the relation of the forces in such a way, that $\frac{T_f}{T_k}$ should be $\cong \frac{T_k}{T_1}$. Taking into account this, as well as the above values of T_f and T_k, we are obtaining the following relationship for T_k:

$$T_k = \frac{T_{10} \times T_8}{T_{10} - T_8}\text{, where}$$

$$T_{10} = \frac{M_{10}}{R} = \frac{2770 \text{ mkg}}{0.9\text{m}} = 3.080 \text{ kg}$$

$$T_8 = \frac{M_8}{R} = \frac{1560 \text{ mkg}}{0.9\text{m}} = 1732 \text{ kg.}$$

With these values

$$T_k = \frac{3.080 \times 1.732}{3.080 - 1.732} = 3.960 \text{ kg}$$

$$T_f = T_{10} + T_k = 3080 + 3960 = 7040 \text{ kg}$$
$$T_1 = T_k - T_8 = 3960 - 1732 = 2228 \text{ kg}$$

The security against slippage:

$$\delta = \frac{T_{\text{running down}} \times (e^{\mu a} - 1)}{T_{\text{running up}} - T_{\text{running down}}}.$$

where μ = friction coefficient between rope and pulley-lining a = wrap.

In case of the employed elm-lining $\mu = 0.2$ while the angle of lap with 3. R distance of the pulley 221° and 45′, for the sake of safety 220°, i. e. 3.84 π.

With the substitution of these values the security against slippage on the 1 pulley (indicated with No 13 on the figure)

$$= \frac{3960\,(e^{9.2 \times 3.84} - 1{,}0)}{7040 - 3960} = 1.485$$

and at the same time security on the II pulley (No 14 on the figure)

$$= \frac{2228\,(e^{0.2 \times 3.84} - 1{,}0)}{3960 - 2228} = 1.487$$

Consequently, the calculated security corresponds to the prescriptions on both pulleys, therefore the driving gear is well and correctly dimensioned also from the point of view of safety against slippage. With reference to the numberings of Fig. 3 the further short remarks should be made regarding the so far discussed Ohnesorge endless haulage, manufactured by the Duclos Mining Machine Works.

The length of this frame is 8.100 mm and it is constructed of rolled section steel.

The driving electromotor (M)

the gear box (G)

the bearings of two driving and the return pulleys (13_x, 14_x and 16_x).

the so-called parking brake (18) connected with one of the driving pulleys parking choks of the service (safety) brake acting on the elastic shaft coupling of the motor are located on a welded framework. The gearings 7—8 and 9—10, accommodated outside the gear box, the pulleys, the service brake and the gear box are shown on Fig. 2 as well.

The motor is a normal slip-ring asynchronous motor, in 6 or 8 pole execution, according to the required rope speed.

The gear box, which includes the reducing and the planet gear, is made of cast iron, in two sections. The lower section serves at the same time as an oil-tank for the oil bath, thus providing perfect lubrication of the gears. The upper part may be easily lifted by means of a hoisting chain suspended in the hooks made in both sides of the section. On the upper section there is also a special filling hole, through which — after the cover is dismounted — the case can be filled with oil. On the sidewall of the lower section of the case a level gauge hole closed by a screw plug for the purpose of observing the course of the filling during the pouring-in of the oil.

Under effect of the gears immerging into the oil — vapours will be generated in the gear-case and thus the perfect lubrication of the bearings located within the case will be carried out. One oil-filling is usually sufficient for a number of months. There is an oil-outlet opening on the bottom of the side-wall of the case. Periodically oil-samples are taken through it to ascertain the necessity of an oil-change. The arrangement of the gears and shafts of the driving mechanism in the case is shown in the figure presented. Of all the toothed wheels only the small wheels will be accomodated outside the case, which are driving the pulleys directly.

All the shafts are rotating on ball or spherical roller bearings dimensioned for the axial pressure. On the case-wall six bearing covers are disposed and after their removal the bearings can be inspected.

The bearings of the two driving pulleys are located on the bed frame so that the axial base of the pulleys is 2700 mm. The axial base of the return sheave is 2800 mm, what is made necessary by its larger diameter. The return sheave is mounted in a somewhat tilted position, so that the rope-strand winding onto the driving pulley and that running down from the return sheave, moving side by side but in opposite direction are not coming in contact. Thus — measured in horizontal direction they will be in a distance of 120 mm one from the other, while in vertical plane — due also to the larger pulley-diameter — the two rope strands will move in a distance of 300 mm one from the other.

The rope strand covering from the track and hauling the full tubs will run up on

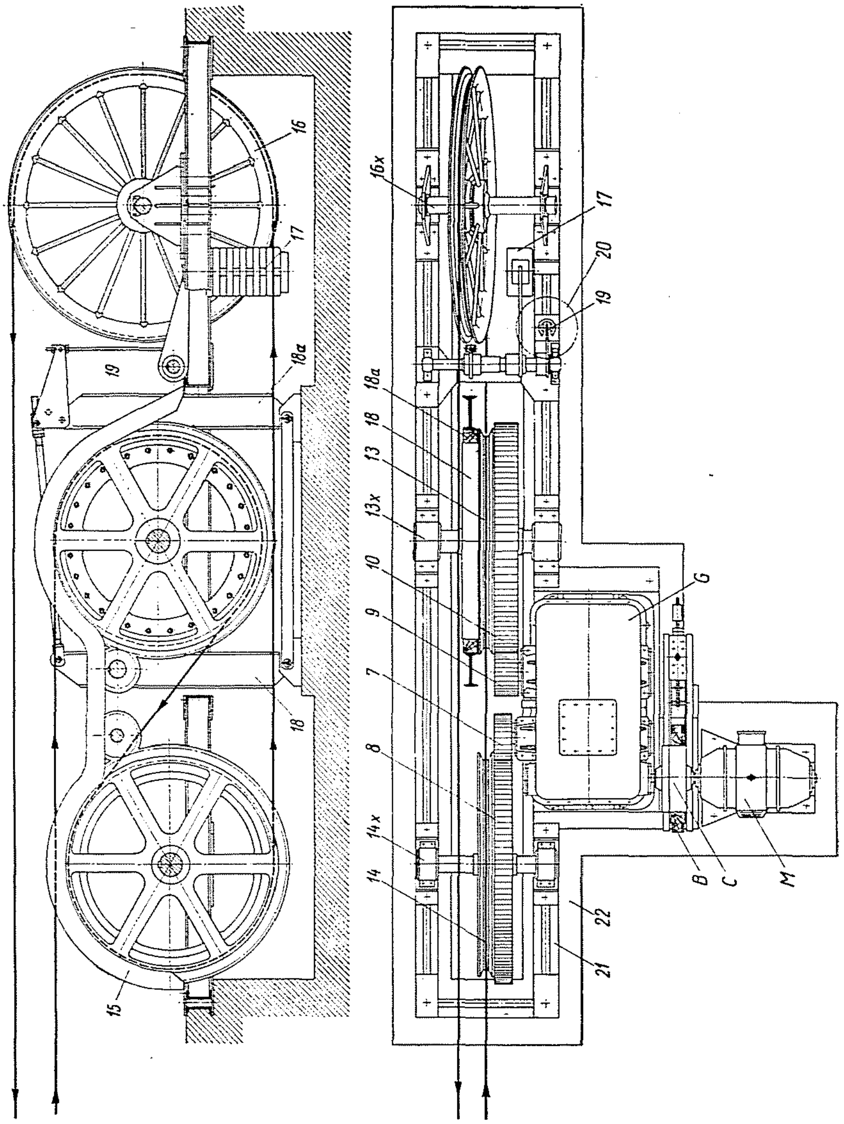


Fig. 3

the driving pulley No I (on the figure No 13). Consequently, it will be here that the largest tractive force will appear. Therefore the brake support (fig. 2, 18) which is constantly braked by a double brake shoe working with a brake weight and is releasable by means of a lifting jack is connected with this pulley. The chocks of this brake are located on the bed frame between the driving pulley No 1 and the return pulley. The brake weight consist of 11 elements each weighing 30 kg, thus its amount may be decreased or increased by changing the number of the elements. The load brake is released by turning off a hand wheel.

Due to the adequate dimensioning the power to be exerted by hand is — in case of 330 kg braking weight —15.5 kg, which can be easily done with two hands. Besides in case of a proper organization of the production and haulage, the haulage equipment is working for hours without any stoppage, consequently the closing of the brake (by letting down the weight), respectively its release (by lifting the weight) occurs hardly two or three times during a shift.

The elastic shaft-coupling of the driving motor forms the brake support of the second brake, the two brake shoes of which are put into operation by a brake magnet. This is the s-ocalled service and simultaneously safety brake, which on the stoppage of the motor or in case of a possible current failure is immediately put in action and prevents the back run.

The main technical data of the endless rope driving gear in question:

Length of bed frame .... 8100 mm
Width of bed frame .... 1200 mm
respectively width on the place of the cast iron case .... 2000 mm
Required height of the machine-space .... 4000 mm

The bed frame is placed on a concrete frame, length and width dimensions of which exceed by 400 to 500 mm the dimensions of the basic frame.

Machine parts having the largest size and highest weight are the following:

Return sheave diameter ...... 2300 mm
Return sheave weight .... 1200 kg

Driving pulley with brake built together with the large gear
external diameter .... 1950 mm
width .... 450 mm
weight about .... 3500 kg

Driving pulley without brake built together with the large-toothed wheel :

External diameter .... 1950 mm
Width .... 300 mm
Weight about .... 2350 kg

On special desire the pulleys may be manufactured in two sections as well, if e. g. the size or weight of the one-section execution would cause difficulties in the transportation, which usually occur in most cases when they are built in underground.

Extreme dimensions of the closed cast-iron case:

Length .... 1820 mm
Width .... 1120 mm
Height .... 1080 mm

Weight of the lower section about .... 1100 kg
Weight of the upper section about .... 500 kg

On suspended track also in underground mining areas the endless rope haulage was very much in favour already 50 to 60 years ago, because it represented a great many advantages as compared with the horse traction usual up to then in the mines. With the low output requirements of those times the call for tractive power was relatively poor, which could be satisfied by a rope laid on a single driving pulley in an arch of 180 degrees. In the one-pulley solution the tension differences appearing is the rope turned up to a smaller extent, the situ-

Table 4

Diameter mm of		Useful tractive force kg.	Rope-tension in rope-strand kg running		Rope ⌀ mm	Motor output HP		Rope speed m/sec	
driving	return		up	down		6	8	6	8
pulley						poles		poles	
1800	2300	4200—4800	6500—7500	2400—2700	23—25	70—80	50—60	1.0	0.75

ation being the same also as regards the wear of the groove lining, thus the former were equalized each time by a slippage and did not cause any particular trouble or emotion. With the gradual rise of the production the output of the haulage equipments and conjointly the necessary tractive-power was constantly increasing. The 180 degrees wrap was not satisfactory any more and a solution with two pulleys became a necessity. The troubles and difficulties have, however, rapidly multiplied along with efforts to eliminate them gave rise to a large number of constructions (among others with two motors), which, however, — prevalently on account of their complicated nature — did not prove suitable. But the production of the mines rose suddenly — particularly when the economic crisis following World War I came to an end — wherefore the endless rope haulage, which otherwise became liked very much and represented innumerable advantages was substituted in many planes by locomotive haulage, which frequently was likewise connected with many difficulties.

In the meantime under the impact of the above-described situation, Ohnesorge, an engineer at Bochum, has about 40 years ago so perfectly resolved the technical problems of the endless rope haulage through tension equalizer designed by him that this haulage system is able to satisfy all the claims and thus the foundations for its widest distribution and general utilization.

LITERATURE

Bansen, Hans: Die Streckenförderung

Braun, Eugen: Die Seilförderung

Grete, R.: Die Zugspannungen an Seil- und Kettenbahnen

Ohnesorge, Otto: Über Maschninenantriebe mit Umschlingen durch dasselbe Seil

Philippi, W.: Elektrische Fördermaschinen

Tipari, K.: Ellenőrző számítások (manuscript)

Vankó, Richárd: Az Ohnesorge-tárcsa feszültségkiegyenlítő jelentősége és alkalmazása.

EXPERIENCE WITH "J"-DIFFUSION ON EQUIPMENTS INSTALLED IN 1959

By

M. TEGZE

Research Institute of the Hungarian Sugar Industry, Budapest

The problems of juice extraction in general, and the results of theoretical and experimental research in this field, carried out by the Research Institute of the Hungarian Sugar Industry, in particular, have been described in a previous issue of the present Bulletin. It was shown there how a process and apparatus for continuous diffusion, called, on account of the shape of the apparatus, the "J"-diffusion, has been developed by Hungarian scientists as early as 1955 when also the first equipment of its kind, a semi-industrial apparatus of 160 tons daily throughput has been put to work. In 1957, the prototype of an equipment for 700 to 750 tons daily throughput has been successfully started: the results of its operation during the 1957 and 1958 campaigns as well as our experience during factory work have also been duly reported.

Experiments and the results of factory operation with the "J"-diffusion equipment have shown that it fully complies with all the various requirements of the modern extraction process as adopted in sugar factories, i.e.

a) good exhaustion while maintaining normal draft;

b) good quality raw juice easy to be clarified;

c) full operational safety both from the mechanical and technological point of view (practical independence of capacity with regard to beet quality);

d) lowest fresh water requirements, exemption from waste water;

e) lowest electrical and heat energy consumption;

f) simplicity of design and attendance;

g) automatized operation;

h) reduced space requirements, and, last not least,

j) low investment costs.

Experience with the new equipment has been such that it was decided to introduce "J"-diffusion gradually in all Hungarian sugar factories. Along with this demand, a number of orders from abroad has been received so that the serial manufacture of the standard equipment of 700—750 tons daily throughput — called the type J-IV — could be started.

The serial type differs only slightly from the prototype of identical capacity; the minor changes considerably increased the simplicity of operation.

In the following we intend to describe the essential features of and the experiences gained with the "J"-diffusion of the type J-IV, installed in 1959.

The apparatus is shown in Fig. 1. From the main measurements appearing there the comparatively-reduced height of the apparatus will be particularly noticed. In case of need, its lower, arched part may even be sunk below ground level (up to 3 m) since it does not contain any element requiring attendance during operation; the only discharge pipe mounted there is operated once a year (end of campaign). The area requirements of the equipment do not appear in the drawing: they are abt. 68 square meters, an exceptionally low figure, representing a particular advantage both when a new factory design or the increase of available factory capacity is intended. Both the low space requirements and the reduced height facilitate the installation of the "J"-diffusion apparatus inside the factory building whereas several other continuous diffusion equipments are usually installed outside of it, a fact entailing considerable disadvantages.

Details as to the water supply of the "J"-diffusion equipment have also been omitted from the picture. These consist of a water-tank, a water-pump and a preheater with a heating surface of 100 m². The simplicity of water supply will be particularly conspicuous in view of the fact that, apart from pulp catching, the cleaning of pulp press water is unnecessary and that pulp press water and pressure water may be fed together into the apparatus by means of a

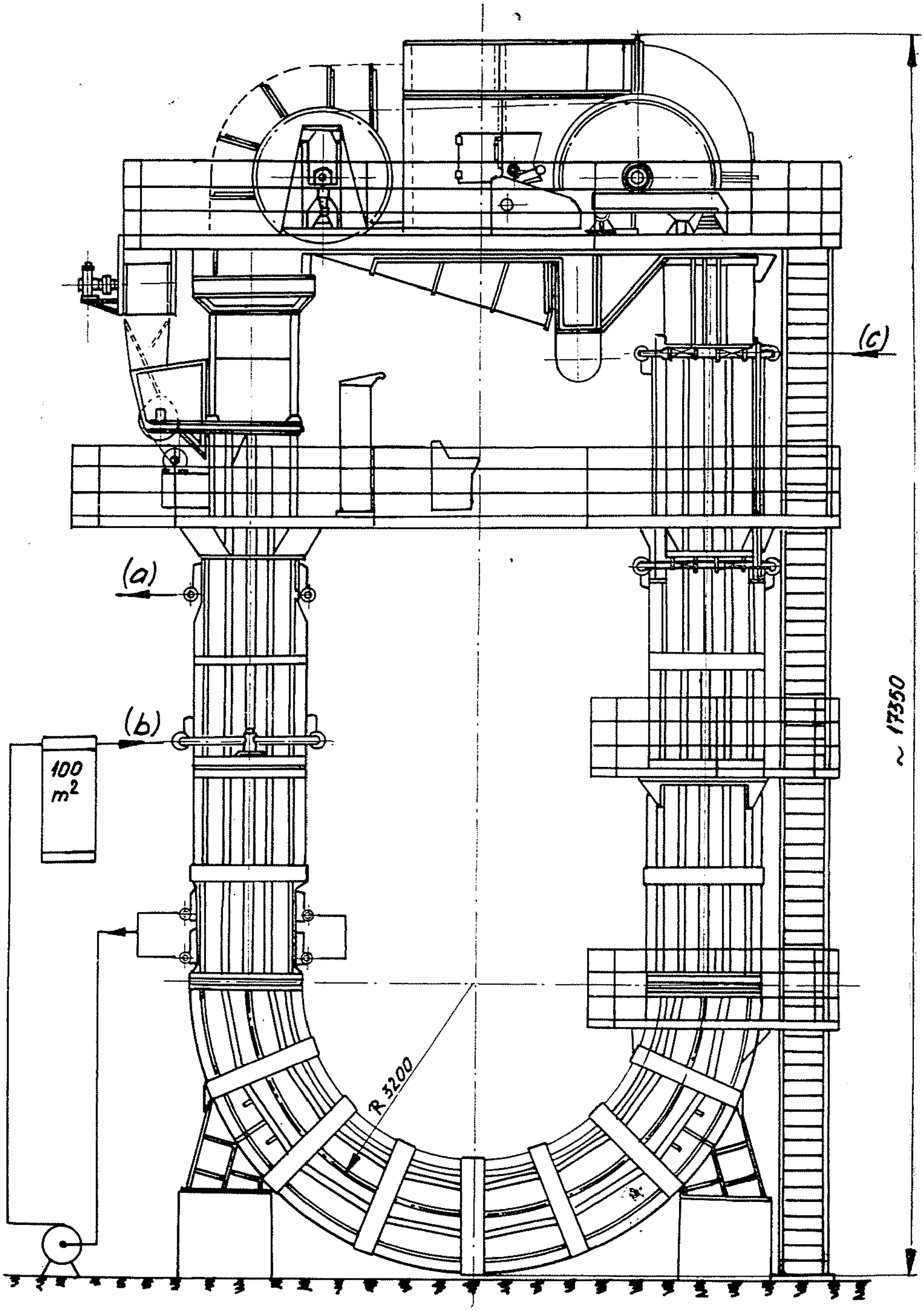


Fig. 1. Outlines of the diffusion apparatus type J-IV (a) Raw juice, (*b*) Recirculated juice, (*c*) Water inlet

single pump. (The reasons for this new feature of the J-IV diffusion will be given later). Thus the attendance of the apparatus is extremely facilitated, the possibility of faulty service still more reduced.

The equipment is attended by one operator only. The operating table is mounted on the level of cossette filling (a new feature of the J-IV type). In this way the operator may observe the quantity of cossettes filled into the equipment and, if necessary, control the output of the beet slicing machines. All measuring and control instruments as well as the results of laboratory measurements transmitted by signal are concentrated on a panel on the operator's desk which are shown in Fig. 2.

The introduction of pulp press water, as mentioned before, has also been modified to some extent, owing to special research in this field. Calculations as to the most expedient way of introducing pulp press water have shown that theoretically, i.e., when considering the extraction process by itself, pulp press water should be best returned a few meters after (underneath) the place where clean pressure water is introduced. The quantitative evaluation of the phenomena has shown, however, that in view of hydrodynamic and control considerations, a mixed introduction of pressure and pulp press water should be preferred, at least as regards the operational conditions of the "J"-diffusion apparatus. Owing to this feature, both the design and the control of the apparatus have been further simplified, and operation results have fully certified the value of theoretical analysis so that "J"-diffusion is operated now uniformly according the said principle. The method has its advantages also with regard to heat economy so that the heat requirements may be reduced below 3.5 kg vapor/100 kg beet provided sufficient quantities of a convenient warm condenser water are available, a possibility that may be ensured generally in sugar factories operating under normal conditions.

Serial production of "J" diffusers has been started in 1959 and is being continued in uninterrupted flow. Owing to time shortage, only two equipments have been put into working order in 1959, one in Hungary (Sarkad sugar factory) during September, and the other in the Soviet Union (Olchowatka sugar factory No. 2, District Woronesh) at the end of the year. In what follows, our experiences with these two equipments will be briefly resumed.

Both equipments have been installed along a Robert diffusion battery working in parallel, in order to increase the effective working capacity of the factory. Moreover, in Sarkad sugar factory the Robert diffusion, besides of being overloaded, was already in a rather worn state. Here the cossettes for the "J"-diffusion have been sliced by two slicing machines of the disc type (manufactured by Láng) one of which was provided with a driving motor with variable speed. The cossettes are forwarded to the charging device of the apparatus through a conveyor belt balance and a steep rake conveyor. The installation of the whole equipment has been carried out by the factory staff without any difficulties and in a short time.

Beet processing in Sarkad started on September 1st, 1959. The "J"-diffusion equipment started working on the 16th September and has worked for 124 days without interruption. Apart from increased output, the start of the new equipment did not involve perceptible changes in factory operation. During the first few weeks, pulp press water has not been returned to the "J"-diffusion, whereas the following 84 days were used to work with full pulp press water return. In the last fortnight of the campaign the pulp catcher of pulp press water went broke so that the return has been discontinued. In the period of pulp press water return, exhausted cossettes, having a percentage of solids of 7—7.5 (i.e., superior to that of Robert cossettes), have been pressed to a percentage of solids of 15.5—16 p.c. and the entire pulp press water was returned to the diffusion. The properties of the exhausted cossettes during pressing and drying differed in no way from those of the Robert battery. The pulp press water was returned through a pulp catcher made of a simple screen and desinfected by sodium hypochlorite equalling in quantity to 0.003 p.c. of active chlorine (on beet).

Extraction results appear in Table 1, where the average results of the campaign and those of the period with pulp press water return are shown side by side.

It may be seen from the above data that owing to pulp press water return, diffusion losses may be considerably reduced: this is in agreement with the theoretical calculations carried out in this respect. It is intended, therefore, to exploit this advantage by an uninterrupted return on pulp press water in 1960 which, apart from reducing diffusion losses, puts an end to the diffusion waste water problem.

In spite of the fact that only one-third of the total available beet quantity has been processed by the "J"-diffusion apparatus, the advantageous extraction results are reflected also in the tabulated extraction losses of the entire factory. In Table 2 appear the data of the entire 1958, and, for comparison's sake, those of the corresponding 9 decades of the 1959 campaign.

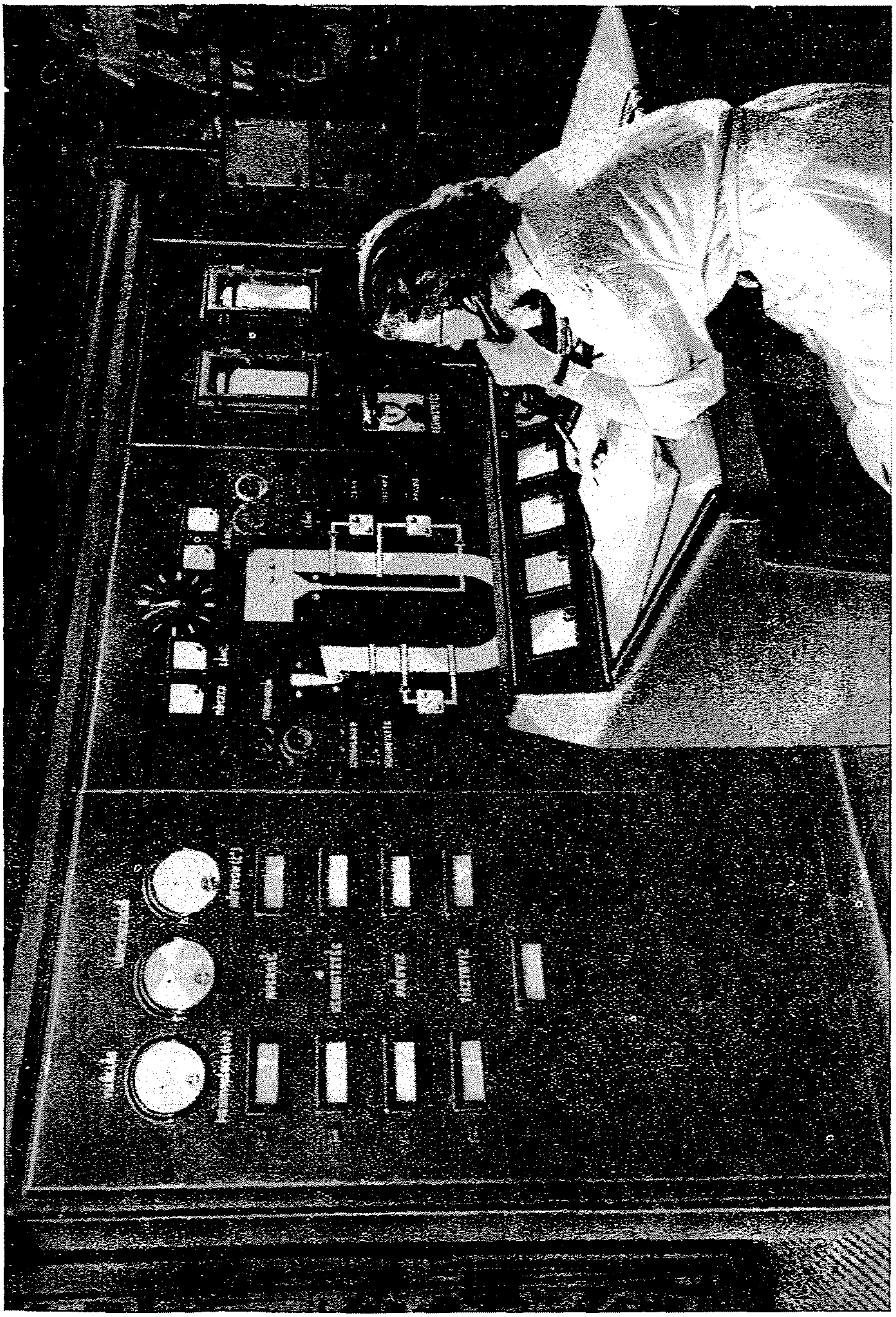


Fig. 2. Instruments' panel and operator's desk

Table 1

	Average of campaign 16—9 to 17—1	With pulp press water return 11—10 to 3—I
Average daily throughput, tons	700	700
Sugar content of beet, p.c.	17.31	17.49
Sugar losses, on beet, p.c.	0.29	0.25
Draft, weight p.c.	122.6	121.3

Table 2

	12—9 to 13—12 1958	10—9 to 10—12 1959
Days	92	91
Daily throughput, tons	1962	2089
Sugar content of beet, p.c.	18.25	17.75
Total loss on beet, p.c.	1.03	0.94

The "J"-diffusion apparatus was fed with cossettes of a length of 20—25 m/100 g (Siline number); effective diffusion time was abt. 56 minutes. Owing to this low figure, the quality of raw juice was excellent though the beets processed towards the end of the campaign were of inferior quality. Juice clarification caused no difficulties whatsoever. It is known that pulp fractions entering clarification together with the exhausted cossettes considerably deteriorate the quality of defecated juice and entail filtration difficulties. The raw juice originating from "J"-diffusion, however, is easy to be clarified because apart from its favourable chemical composition owing to the shortness of diffusion, it is leaving the apparatus exempt of foam or pulp fractions so that neither anti-foam agents nor extra pulp-catching devices become necessary.

As to actual figures, the average purity coefficient of the Robert raw juice was 86.3 p.c. that of the "J"-diffusion raw juice 86.4 p.c. Control measurements made at the end of October by the staff of the Research Institute (30 measurements) have given 88.1 and 88.2 p.c., respectively. Thin juice processed in the laboratory from raw juice according to Siline's method have shown the agreement of the purity coefficients, as well as of the ash and calcium salt contents of the juices originating from the two different diffusers within the margin of error (in spite of the fact that the "J"-diffuser operated with pulp press water return, and the Robert-battery without it).

The microbiological environment in the "J" and Robert-diffusion has also been investigated. The germ counts are shown in Table 3.

It will be seen from these figures that the number of thermophiles is about a hundred times smaller than that of mesophiles. The number of the latter in the "J"-diffusion is lower by one order of magnitude than that of the Robert-battery. With regard to the fact that also the battery has been systematically desinfected, this difference may be attributed primarily to the automatically-controlled temperature conditions in the "J"-apparatus.

That the microbial activity in the "J"-diffusion was considerably smaller could be shown also by determining the quantity of nonsugars originating by sugar decomposition. For this reason, the quantities of invert sugar, lactic acid and volatile acids, introduced into the diffusion with the cossettes and the pressure and pulp press waters, and leaving the diffusion with the raw juice, the exhausted cossettes and (in the case of the Robert-battery) with diffusion water, have been determined. Total material balances obtained as a result have shown the superiority of the "J"-diffusion apparatus also in the field of unknown losses (see Table 4).

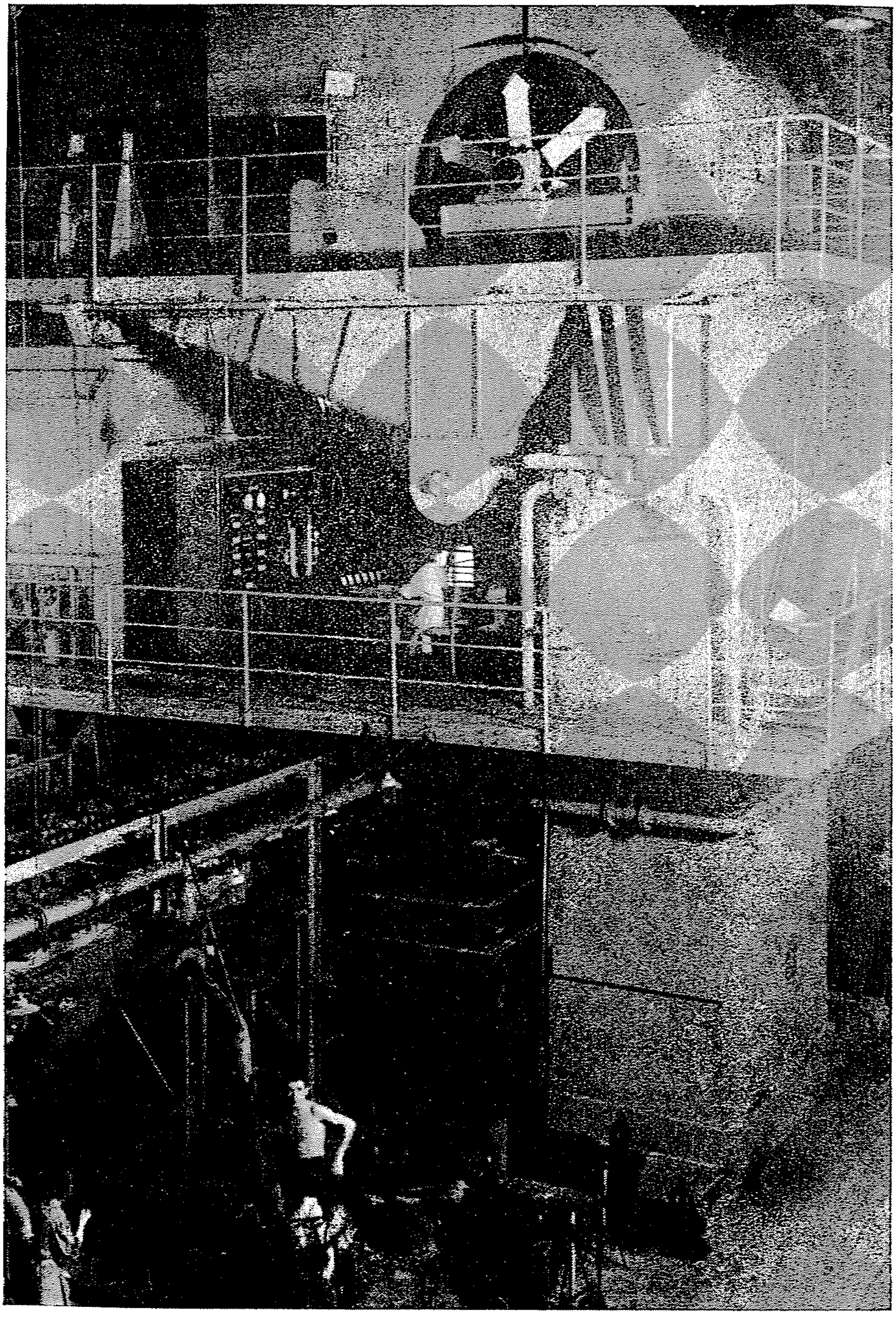


Fig. 3. The J-IV diffusion apparatus in Sarkad sugar factory

Table 3

	Mesophiles/ml		Thermophiles/ml	
	in the centre of the apparatus	in the raw juice	in the centre of the apparatus	in the raw juice
Robert-diffusion	$3.10 \cdot 10^5$	$12.10 : 10^5$	$5.58 \cdot 10^3$	$3.50 \cdot 10^3$
"J"-diffusion	$0.34 \cdot 10^5$	$5.00 \cdot 10^5$	$5.22 \cdot 10^3$	$3.65 \cdot 10^3$

Table 4

	Invert sugar p.c.	Lactic acid mval/100 g	Volatile acids mval/100 g
Robert-battery	0.038	0.19	0.42
"J"-diffusion	0.008	0.18	0.12

Apart from the technological characteristics shown above, it must be emphasized that also from a mechanical point of view, the "J"-diffusion equipment in Sarkad sugar factory worked beyond reproach, a fact that is also demonstrated by its uninterrupted operation for 124 days. Also during supervision at the end of the campaign no mechanical irregularities could be detected.

Also from the hydrodynamical point of view, we have to emphasize that the equipment operated without any difficulty so that a shortening of throughput was never required, not even when, in January, deteriorated beet had to be processed; plasmolysis temperature, of course, had to be lowered, accordingly.

Another "J"-diffusion apparatus of the J-IV type has been installed in the Olchowatka sugar factory No. 2 (Soviet Union). Also here the newly-installed apparatus worked in parallel with the existing Robert-battery. The equipment was mounted and started by the factory staff under the direction of Hungarian specialists. At the time of the installation weather conditions were extremely unfavourable (outside temperature approaching —40° C) so that the beet material was frozen right through. As a result, it was impossible to prepare cossettes of normal quality; the beet-slicers produced considerably thicker cossettes with a large proportion of fragments. Also in the later period of the campaign, cossette quality and length remained considerably inferior to usual conditions: this, of course, must necessarily impair extraction results. Besides, local conditions did not allow to press exhausted cossettes from the "J"-diffusion separately nor was there a possibility of returning pulp press water. This shortage entails additional sugar losses of abt. 0.10—0.15 p.c. as has been ascertained both by experience and calculation. None the less, total extraction results were favourable as it is illustrated in an article by V. A. Selyatitskii, of the Planning Office of the Russian Soviet Federated Socialist Republics, in the journal Sakharnaya Promyshlennost' (34. 1950. No. 4. pp. 14—15.) which runs as follows:

"In the Olchowatka sugar factory, the apparatus operated with an average daily throughput of 7.5 thousand metric centners while sugar losses in exhausted cossettes amounted to 0.25—0.4 p.c., draft on beet weight being 123—130 p.c. The maximum throughput was 8.4 thousand metric centners, with a sugar loss in exhausted cossettes of 0.4—0.5 p.c., the draft being 126—130 p. c. In individual shifts with well-adjusted and productive work, the sugar losses in the exhausted cossettes amounted to 0.23—0.28 p.c. on beet weight (sugar losses will diminish with the return of pulp press water)."

The attendance of the "J"-diffusion apparatus was quickly learned by the staff of the factory. Experience has shown that this was facilitated by the correct location of the central instrument panel and of the control and regulating instruments. In the the above article, the operation of the "J"-diffusion equipment is commented upon as follows:

"The apparatus operates rhythmically. It is attended by one operator. The process of diffusion juice recirculation and pressure water heating is entirely automatized.

"Automatic control of the diffusion process is particularly well executed. All the measuring instruments of automatic control are concentrated on a special instruments' panel.

"All analytical results relating to the work of the diffusion apparatus are automatically transmitted from the laboratory to the attendant's desk. The quick implementation of all necessary measures is thus facilitated.

"It was decided to install several diffusion equipments of the same type during 1960 in the sugar factories of the Soviet Union.

"...It should be mentioned that the construction of the J-IV diffusion apparatus is compact. Owing to the well-designed cossette-forwarding equipment, the diffusion process is carried out much more thoroughly than in other diffusion equipments."

All these outstanding accomplishments of the J-IV apparatus (good extraction, good quality raw juice, indifference to beet quality) have led, side by side with the gradually increasing inland demand, to a growing interest for "J"-diffusion equipments from abroad. Owing to the daily performance of 700—750 tons of the J-IV type, it is, as shown in this paper, particularly suited for smaller factories for the increase of factory capacity. Nevertheless, the growing interest for constructions capable of a considerably larger daily output faced the constructors with the task of designing a larger unit, while reducing the specific weight and the relative costs of the equipment; at the same time, however, the space requirements were to be kept as low as possible. In consequence, a new equipment for a daily throughput of 1500 tons has been recently designed; its height is 19 m (i.e., only 1.5 m more than the height of J-IV) while its area requirements amount to 90 square meters. In the course of 1960, the first equipment of this kind will be put to work in Hungary in order to ensure the possibility of a serial production for inland and export purposes during the following year.

EQUIPMENT FOR RENDERING OF FAT

(Patents of Emeric Németh)

By

K. Pál

There are two different methods to clarify the fat content of animal tissues containing fats:

a) The dry process

b) The wet process

The continuously-operating equipments we are acquainted with use the wet process for clarifying. The systems based on dry procedure have been operating discontinuously so far.

The continuous rendering equipments (systems Titan or de Laval) adopting the wet procedure add water or aqueous vapour to the tissues containing fats.

A cell-wall hydrolysis is going on under steam pressure with water being present and holds on until the fat becomes partly liquefied and the fats that are relieved of the cells get to the surface of the water.

However, the equipments, the operation of which is based on the wet process have the following disadvantages:

During the rendering the fat is in permanent contact with water steam and as a result of the heat effect it is also touching divalent bicarbonates. Their contacting fatty acids result in salts insoluble in water. Moreover, a certain part of the disintegrating bicarbonates bring about incrustation resulting in certain inevitable troubles as to the continuity of the operation.

There is another disadvantage created by the fact that the fat melts in the water, involving the application of centrifuges in order to segregate fats from water.

It is inevitable, however, for the water segregated centrifugally not to carry some fat along. The above-mentioned loss of fat converted into primary materials (raw fat) involve a 0.5—0.6% loss.

The dry process rendering equipments hitherto known are discontinuously operated. The point is to abstract the water-content of the fat tissues to a certain extent allowing the cell-walls to burst and the cells to discharge the fat.

Melting takes 3—4 hours time as to the discontinuously operating equipment working on the dry process. This long period results in the enrichment of fats, as far as fatty acid and peroxide is concerned and has at the same time a disadvantageous effect on its quality and durability. The output of these equipments is comparatively insignificant, with a rather high consumption of specific heat and energy.

The dry rendering process working on system Németh is void of all said drawbacks and even has the following advantages over it:

1. It may be applied for the rendering of pig-bacon and leaf-lard, beef-tallow or any other fats of animal-origin.

2. The grease has a much more pleasant taste as against the fats being rendered by the wet process, as they have no flavour, whatsoever.

3. As against the rendering period of 3—4 hours by discontinuous process, melting, clarifying and cooling of the fat takes no more than 60—70 seconds in all. During this short melting-period there is no danger of increasing the fatty acid and peroxide-content, thus enabling its storability and durability as never experienced.

4. The continuous, dry process brings about a never-experienced fat-yield.

The special advantage of this equipment is the same efficiency shown when rendering smaller quantities as in case of operating with full capacity.

5. The protein-content of the fat produced on basis of the system Németh never decomposes and retains its vitamincontent to a higher extent than ever known hitherto.

6. Manpower required: 8 operators;

considering an output of 20 tons within one working shift (8 hours)

7. The equipment secures the maximum protection of health.

8. Not more than 5 minutes are required for making the equipment ready for working. Switching off the equipment takes 5 minutes likewise.

9. The steam required for the melting process and water for cooling the fat may be recuperated and being free of any foreign impurity — can be recovered or utilized for any other purposes.

10. The parts of the rendering equipments, having been in use so far, such as machines or other elements (doublewall duplicator, vacuum or pressing-boilers) may be connected to the fat-rendering equipment working on system Németh.

Cleaning of the continuously-operating equipment is to be performed daily by washing it first in sodic water and scoring it then with hot water. This operation takes altogether not more than 25—30 minutes time.

ELECTROSTATIC PAINT-SPRAYING EQUIPMENT

By

J. Domokos

The basic principle of electrostatic paint-spraying has already been included in the Möller-system scrubbing filters and on basis of this well-known principle many patents have been appeared in different countries. The common idea of such patents was to deliver the finely atomized paint-mist — almost without any loss — on the components to be painted.

We do not wish to deal this time with the forms and discharge of the electrostatic field and powers, the charge build-up of the particles, the motion of the paint-particles and the theoretical analysis of their attraction with the workpiece — we simply want to refer to the advantages of the electrostatic paint-spraying process on basis of the modest results obtained in our electrostatic laboratory. We want to give a concise outline of the four electrostatic processes being applied by plants having a higher production as far as piece-numbers are concerned and/or which are fighting for a manufacturing level being higher and more progressive than hitherto.

These processes are the following:

1. Electrostatic paint-spraying with the help of an electric grid.
2. Electrostatic paint-spraying by means of a spray-electrode.
3. Disc-type spraying-process.
4. Electrostatic detearing of tears.

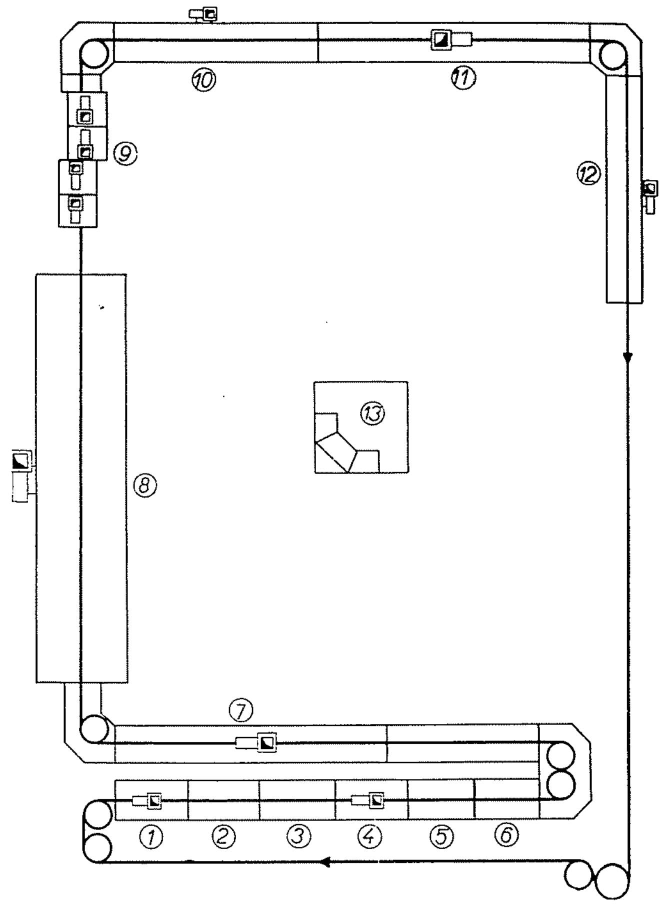
To 1. The principle of the equipment employed in connection with this kind of electrostatic paint-spraying corresponds to the working of the scrubbing filters. According to it, the primary current taken from the network is passed on to the primary terminals of a high voltage transformer. Passing the current from the output terminal through one or two selenium metal rectifiers or valve rectifier or else, through dry rectifier producing direct current which may also casually be filtered by means of a filter capacitor, connected after the rectifier.

The electrode-grid will be connected to this negative pole, surrounding the object to be painted on three sides by means of 0.3—1.5$^0/_0$ mm diam. wire electrodes, stretched close to each other. The wire electrodes are going to be stretched on a tubular frame work, resulting a cage-form. The workpieces being painted are placed into the coating zone surrounded by the cage, and connected to an earthed potential.

When passing paint-particles from a paint-sprayer (spray-gun, spraying-disc, spray blade, etc.) from a position outside the space, energized and surrounded by the electric grid at the lowest possible air-pressure i. e. at an atm. pressure of 0.4—1, the paint-particles building up a negative charge make them move to the earthed workpiece. (See Fig. 1.)

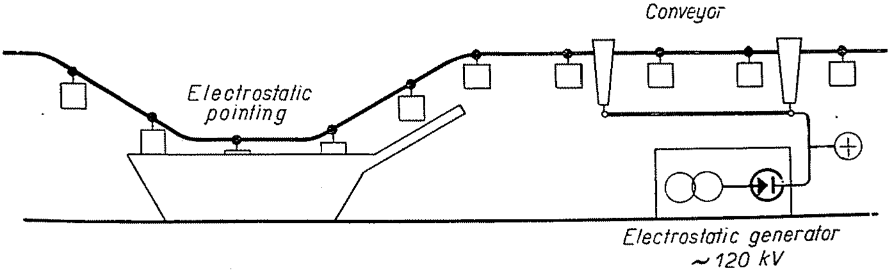
To 2. The principle of electric control is the same as in the case of 1, only the wire-electrodes are omitted and spraying is carried out besides a low-pressure spray-gun by so-called spray-instruments, which are atomizing the paint particles from a rotating, circular-shaped edge or from a straight fixed edge, thus utilizing the point effect of the edges. The spray-electrodes are directly connected with the negative terminal of the D. C. high voltage. The conveyor, and, hanging on it, the work-piece to be painted are earthed here too. The current intensity cannot exceed, as a rule, 2 mA; wherefore in this case a special electrode grid is not required. Consequently, all difficulties arising at the use of spray-guns and wire-electrodes which finally lead to a higher loss of varnish can be omitted. Regarding the fact that about 90 to 95 p. c. of the atomized paint deposited against the work-piece, the air-exhausting performance may be reduced to about 10 p. c. of the usual one. A spray-instrument as this one substitutes for 3 to 4 paint-spraying skilled workers.

The spray-instruments may be adjusted by the help of pivoted arms, consequently,



10
11
9
12
13
8
7
1
2
3
4
5
6

Fig. 1



Conveyor
Electrostatic
pointing
Electrostatic generator
~120 kV

Fig. 2

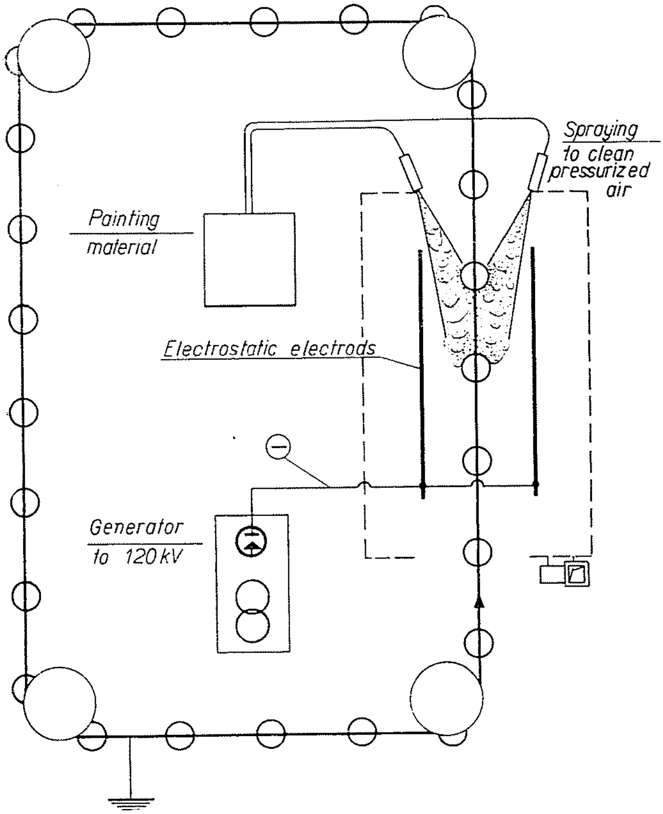


Fig. 3

they can advantageously follow the shape of the work-piece to be painted, with a view of economical deposit. The spray-instrument may be even moved up and down along the workpiece to be painted (see Fig. 2).

To 3. The disc-type spraying-process is, fundamentally, identical with the procedure discussed under 2, with the variant, however, that paint-particles going to be atomized not by means of a spray-instrument rotating in a vertical plane but along the edge of a special disc of vertical axle, of high revolution number rotating in a horizontal plane and, which, at the same time, may move up and down. The conveyor moves in such case around the spray-instrument. The objects may be painted on both sides either by rotating the work-piece or by constructing two conveyors of opposite hollowness in which case two spray-instruments are used simultaneously. (See Fig. 3.)

To 4. The electric control is the same as in case of *1.*, *2.* and *3.* with the difference, however, that the object to be painted, or more precisely, the belt conveyor and the wire mesh electrode, placed under it, are connected inversely. Consequently, the negatively-charged paint-particles of object painted by means of dipping or, correctly, the particles which became superfluous due to overspraying, detair from the surface and are deposited on the earthed electrodes. This method is particularly recommended when reactive wash primers are applied in which case the undercoat, containing also well-dissociable components is excessively conductive. (See Fig. 4.)

As to the methods mentioned above, particularly the process described under Para 2. has gained currency.

The electrostatic paint-spraying by the help of spray-electrodes, being the typical procedure as to middle- and mass-production has gained more and more ground in countries with industries on a highly-developed level.

The workpieces to be painted are conveyed continuously between the spray-instruments. As a rule, the speed of the conveyor (chain, running belt) may vary from 0.5 to 5 metres pro min., but there is also a possibility of constructing conveyors of higher speed. In many cases the conveyor is run in a tube and is greased automatically.

For applying along the conveyor chain one undercoat primer and one or two coatings, it will be practical to use altogether two to three electrostatic spray-booths. In case of smaller products it is more advisable to combine one dipping and two spray-booths. The layout of an electrical spray-booth is shown by Photograph No. 1.

Taking into consideration that it is not necessary in every case to rotate the workpieces to be painted,*** the booth is characterized by the diagonally opposite placing in sections of the spray instruments. The diameter of the discs, the distance to be adjusted between them, and the height of above-ground placing may be accurately regulated in conformity with the shape of the workpiece to be painted.

On the opposite side of the spray-instruments, at equal distance from the conveying chain may be placed the so-called earth-plate which, for reasons of cleaning, should be covered with a replaceable wall-paper with the aim to collect and hold fast the very small quantity of lacquer that may scatter around it. The minimal loss of paint is well-characterized by the fact that at such equipments running in the way described above is to be replaced every second week only.

The chain conveyor belt suspended in the central line of the booth does not require any protecting covering against paint-contamination, neither does its surface need any special greasing, since the chain race runs in a tube.

Regarding the fact that the specific weight of the solvent used is heavier than air, the ventilation of the spray booths is to be ensured from the top in the direction of the pedestal. The suction air-gap, placed at the bottom of both sidewalls of the spray-booth is to be equipped with a screened device, with a view to adjustability and it is also advisable to keep depression in the spray-booth in order to protect the air in the workshop from contamination. The artificial lighting may be realized by means of neon tubing, behind glass plates in two upper corners of each spray-booth (it is also advisable to use fluorescent light).

The floor of the spray-booth is to be made of cement or paving brick, or else should be covered with asphalt; their close-walls may attractively be shaped with the utilization of steel structural elements and glass plates. It is not advisable to use inflammable parts.

The paint-supplying may be adjusted with the help of rotary gear pumps with an accuracy of 0.5 cm^3 pro min. The process of atomizing is carried out by spray-instruments conveniently applied in groups of two or three. Their diameter is generally characteristic while shape and performance vary according to the size of the workpiece to be painted. The material of the spray-instruments may be aluminium, silumin, or any other coloured metal alloy, which are going to be polished inside the instrument while the edge of the atomizer will be ground sharp to an appropriate angle in order to increase the point effect. The number of revolutions may be adjusted in conformity with the spray angle required by the size the workpiece to be painted. The feeding of the paint by the spray-instrument shall be ensured by means of an appropriate connecting tube, either through the axle rotates the spray-instrument or by means of another mechanism of a particular duct.

Depending on the distance required between the spray-instrument and the workpiece to be painted a paint of adequate conductivity shall be used. In regard of the breakdown spark gap, plastic insulators of appropriate length, shape and strength shall be used between the system of spray-instruments and feeding pumps and the earth. With a view to facilitate the cleaning of the insignificant amount of back-scattered paint-particles, the metal parts of the spray system may be thoroughly greased with neutral vaseline.

In connection with the rotary gear pumps we have to point out that a separate spray-head is to be operated at each disc type, the accurate adjustment of which ensures the uniformity of the paint supply. However, as a rule, one rotary gear pump system feeds four to six spray-instruments with paint.

Further on, we should like to examine the most important safety precautions which must be applied as regards electric shock-proofness and protection againts fire-hazard at every equipment of 60—150 kV effective direct-current voltage and 2 mA maximum output intensity, which precautions have ensured full accident prevention as to the electrostatic plants erected by us according to our own experiences. In the space between the emitting electrodes whether wire electrodes or spray-instruments and the workpiece, the voltage gradient optimum, at which a dark discharge, i. e. a corona current break-out may take place, is 3500 to 5000 V/cm.

*** between the spray-instruments

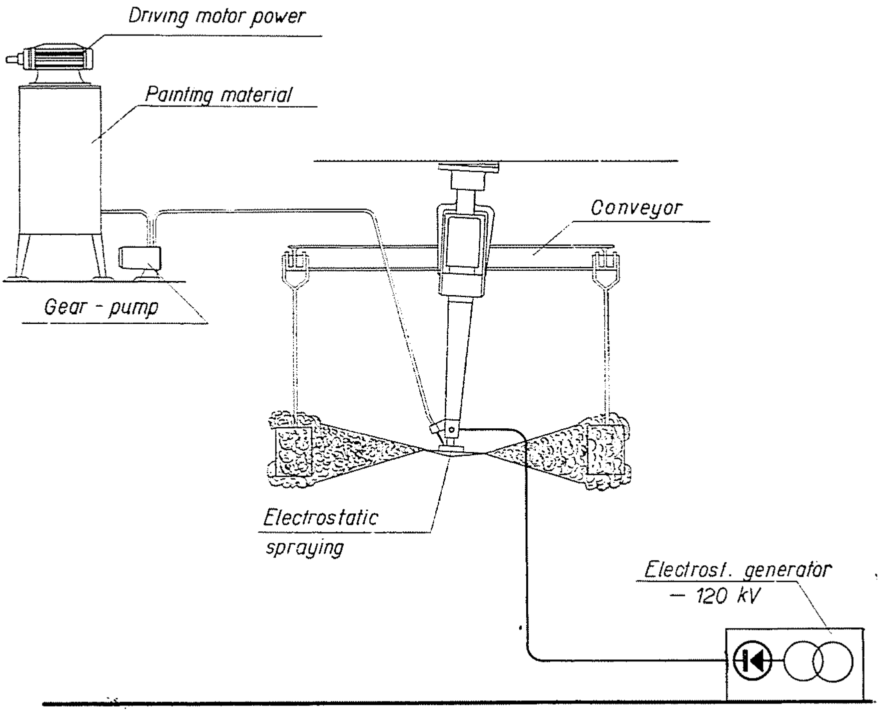

Driving motor power
Painting material
Conveyor
Gear - pump
Electrostatic spraying
Electrost. generator — 120 kV

Fig. 4

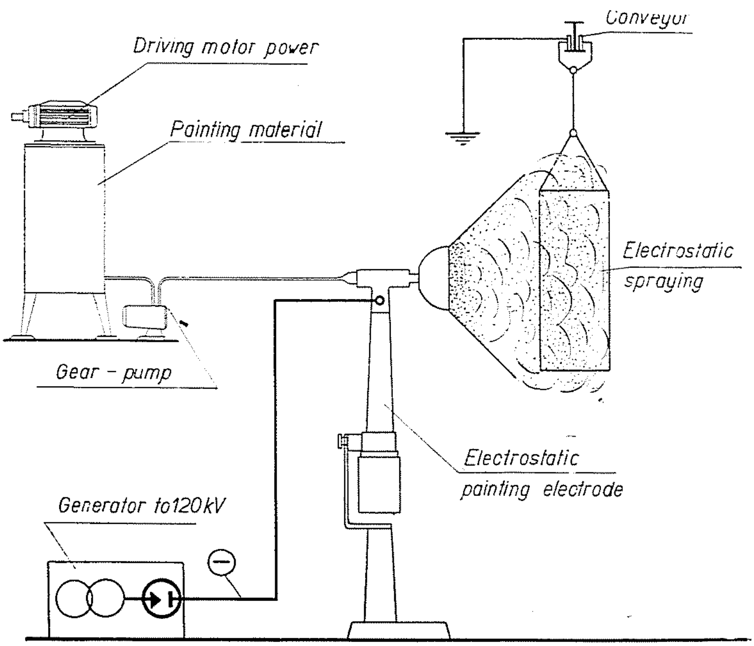

Conveyor
Driving motor power
Painting material
Electrostatic spraying
Gear - pump
Electrostatic painting electrode
Generator to120kV

Fig. 5

At 7000 V/cm, however, there is already a possibility of bright discharge which — in case it should hold certain time — would have the chance of transmitting a great amount of energy to the solvent air-mixture to such an extent which could lead to fire or explosion, unless an adequately-dimensioned exhauster functions – besides the resistance, giving protection against sparc arc, to be discussed later — which keeps the concentration of the above-mentioned mixture in a reliable way below the dangerous liminal value. The main protection, however, is represented by an inertialess buffer resistance, interpolated between the electrode and the rectifier, being dimensioned in a way so as to come cut off at too high voltages, thus preventing the passing through the spark-gap of such an amount of current that may be able to ignite the mixture of air and solvent. Besides all these precautions, it is advisable to equip the spray-booths with automatic carbon dioxide-gas extinguishers too.

The safety, however, is mainly based on a positively-coupled system, in consequence of which the connecting-up of the entire electrostatic painting can be effectuated merely by the following sequence of the individual operations of the connecting system of the centrally-located control desk:

a) main current
b) exhauster fan
c) blower fan,
d) safety resistances,
e) high voltage without actuating switch,
f) rotary gear pumps,
g) spray-instruments,
h) conveyor belt,
i) door contact, i. e. a circuit of current closing at the shutting of the door of the electrostatic spray-booth
j) high voltage,
k) other parts, the actuation of which may be wanted (infrared drying panels). (See Fig. 5.)

The electrostatic plants we manufactured have been successfully working and have filled all requirements as to productivity and saving of material. Photograph No. 2 shows the centralized control and, moreover, shows the fact that besides the actuating key board, all necessary electric measuring instruments and telethermometers are to be found on the control desk.

The workpieces hung on the conveyor, forwarding continuously, perform — if necessary — a rotary movement, too. The cubic air-volume of the space surrounded by the electrodes is about 1500 liters. The workpieces which have been conveyed here are already in unrusted, degreased, and eventually, phosphatized condition. The spray-instruments that are arranged here surround it from different sides, adapting themselves to the dimensions of the workpiece.

The ventilating of the spray-booth is effectuated by centrifugal ventilators of a considerably lower hourly cubicmeter output than it has been in use as regards hand-spraying methods. The air-supply, being exhausted is effectuated by supplying, according to need, heated and dedusted air in a quantity which has to create an inside depression in respect of the air outside the electrostatic booth.

The continuous supplying of the paint to the spray-instruments is realized by means of an appropriate number of paint-containers, having a capacity of 30 to 100 liters each; the stable consistency of the paint in the container is ensured during exploitation by a rotating stirring blade. The operation of refilling may be effectuated without stopping the electrostatic exploitation. The quantity of paint to be forwarded to the spray-instruments in quantities which can be regulated very accurately by means of a rotary gear pump, thus, without any fluctuation. The effect of the rotary edge system spray-instruments, may be — if necessary — complemented by adding a stationary spray-instrument for compressed air. According to the speed of the chain-conveyor several spray-instruments may also be erected. In case of a lasting standstill, the spray-instruments and their wires, respectively, shall be switched over to idle running, if necessary, solvent or compressed air — with a special view to colour change — may also be connected to them.

The spray-instruments act at the same time as electrodes too, consequently, they connect the negative pole of the direct current. The electrical source should be set either at the side of the booth or — pending on the height of the workshop — preferably on the top of the booth; in both cases in a separate space. After the painting process the suspended work-pieces shall be dried by means of infrared heat-radiation with a wavelength according to the mass of the mass of the workpiece. The drying time — and accordingly the output of the drying tunnels — depend on the bulk, the spatial arrangement and the surface form of the components, as well as on the speed of the conveyor.

Another factor, not to be neglected is the selection of an adequate type of paint since only those can be used in the electrostatic field which do not deposit and the conductivity being in the region of 10^{-6}—10^{-9} S. We do not wish, however, to discuss the characteristics of the various paints within the scope of the present treatment.

The electrostatically-transported paint-consumption is 0.10 to 0.12 kg/m^2, which in comparison with the hand-spraying process, means the saving of 50 p. c. in material. The new method contains other important sources too, which enable to realize the increase of the productivity of labour, i. e. the utilization of spray units with openings of various diameters of disc type spray heads, the augmentation of the number of the spray units, raising the output of the paint pump, the practical forming of the suspension of the work-piece, etc.

Besides the painting of metal pieces, this method is suitable also to paint spraying rubber, wooden, leathern and plastic work-pieces.

The working and hygienic conditions of the working personnel are greatly improved, which fact is due to the automatic operation of the paint-spraying equipment, since the work of the labourors is confined to the remote control of the paint-spraying equipment. This also means that the employment of skilled workers, whose insufficiency was always perceptible is indispensable any longer.

By means of the equipment, in conformity with the technology required, a coat of paint, having a thickness of 50—120 microns may be formed. In case the pieces to be painted should have such sunken hollows which might qualify as the criterion of the Faraday-cage, a supplementary hand-spray operation stand is to be established, where the hand-spraying treatment of such hollows could be ensured either automatically or by means of a manual operator, without interrupting the continuity of the chain road.

According to our own experiences, the painting costs may be reduced by 30 to 50 p. c., consequently the amortization of the investment is very favourable.

The preliminary condition for a safe operating here also in the systematic maintenance which requires a careful control of the electrical and mechanical equipments and their thorough cleaning, to be repeated at least every second week.

The savings obtained by using an electrostatic installation have the following main values of an informal character:

Saving of paint quantity	50 p. v.
Reduction of personnel	30 p. v. as a minimum
Decrease of general factory overhead	25 p. v.

The electrostatic paint-spraying process which keeps spreading without interrupting the continuity of the chain road undoubtedly have technical and economical advantages. Nevertheless, it must be admitted that a favourable and advantageous lacquering of all possible profiles cannot be expected of this method. The hand-spraying methods will not be omitted when it is the question of manufacturing pieces of a limited number, as well as in case of painting technology of very intricate surfaces. Nevertheless, the utilization of the new process is unquestionably beneficial as far as middle and mass production is concerned.

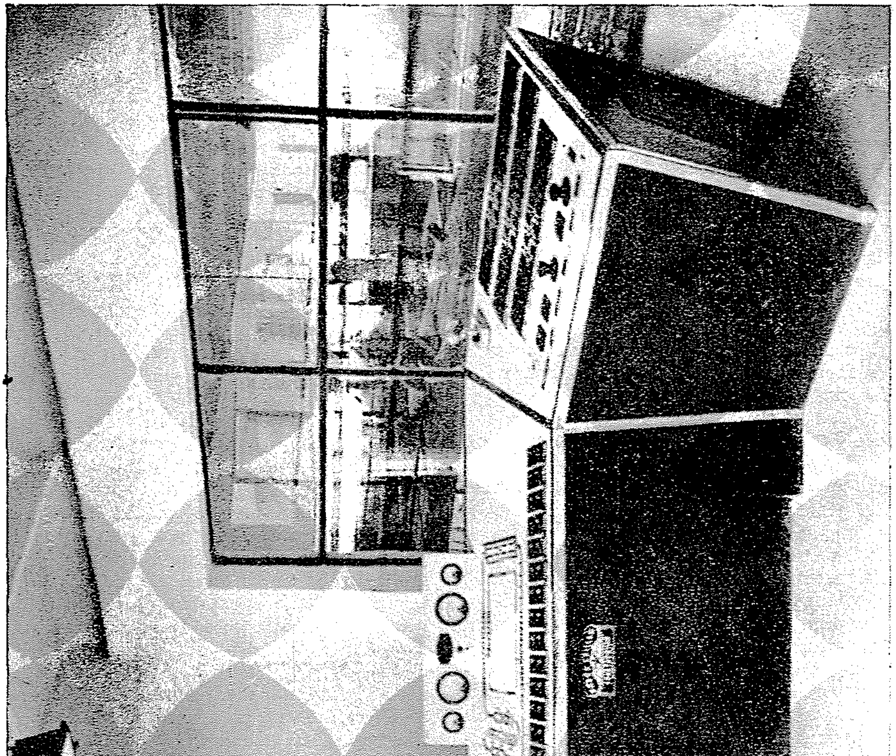
The electrostatic paint-spraying being the typical process of the serial and mass production, it is indispensable to employ an adequately traced and continuously advancing conveyor for the tranportation of the workpiece to be painted, as well as an appropriate shop surface and height of exploitation, as required by the conveyor. The advantages of the process may be utilized at a large scale by employing workpieces of approximately identical shape and sizes, although, with a correct hanging technique, work pieces of quite different sizes may also be painted satisfactorily by means of the electrostatic paint-spraying process.

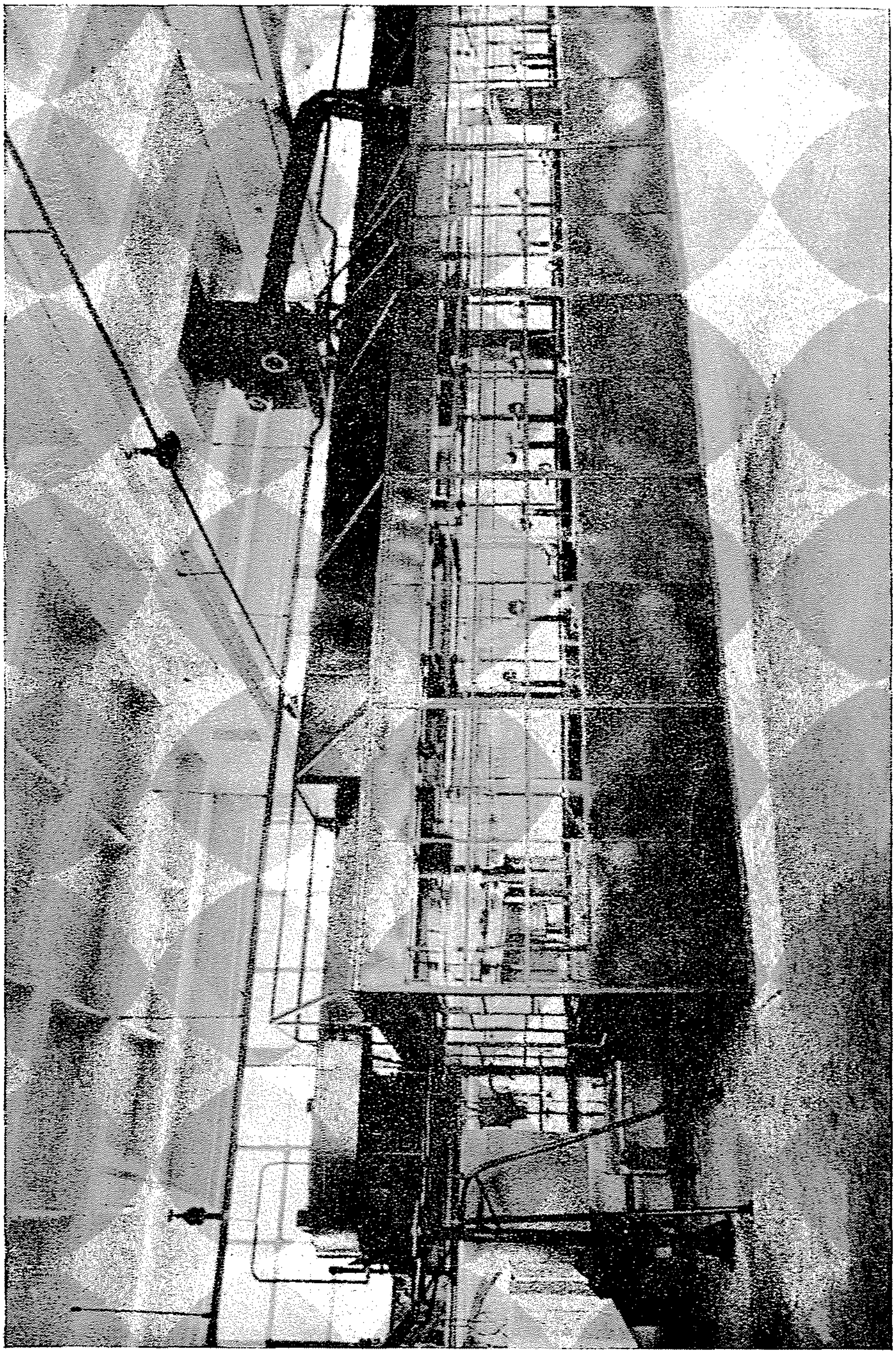
The dimensions of the electrostatic paint-spraying booth, as well as the number and position of the spray-instruments are determined by the largest workpiece and therefore the smaller objects must be grouped accordingly. In certain cases it may prove useful to exclude workpieces of rare occurrence and of greatly abnormal dimensions from this procedure in order to turn the advantages of the electrostatic painting to the profit of the main bulk of the production.

Our industry is well-experienced in the manufacture and operation of electrostatic paint-spraying equipments.

Equipments of our "Electrospray" model are put on the market by the Hungarian Foreign Trade Company: „KOMPLEX"

pp. 1—2 Electrical power supplies
Electrode grid
Paint container
Spray-instruments
Diagram of paint spraying using grid electrode
pp. 2—3
Stirring machine
Paint container
Fountain
Electrical power supply
Conveyor
Workpiece to be painted
× Nozzle (Jet)
Isolator
Diagram of Electrostatic Paint spraying, bell-type process
pp. 3—4.
Driving mechanism of the Stirring Machine





Pump Paint container Conveyor
Disc Electric power supply

Diagram of Electrostatic Paint spraying, Disc-type process
pp. 3—4

Electrode grid
Dipping bath Electric power supply

Diagram of Electrostatic Paint spraying, detearing process
pp. 8—9

1. Degreasing
2. Cold-rinsing
3. Hot-rinsing
4. Phosphatizing
5. Cold-rinsing
6. Hot-rinsing
7. Drying
8. Electrostatic spray-booth
9 Hand-painting booth
10. Straining
11. Infrared drying
12. Cooling section
13. Control desk

Lay-out of an electrostatic painting plant

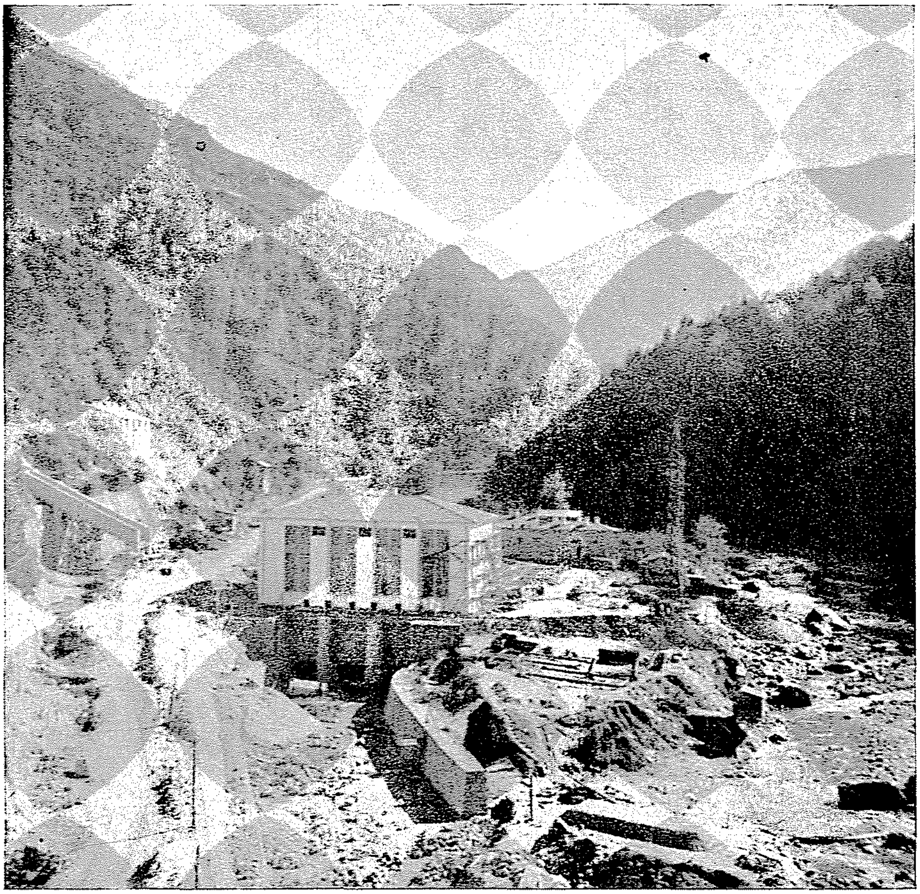
THE CONSTRUCTION OF THE RIZE–IKIZDERE HYDROELECTRICAL SYSTEM

By

E. Zsák

B. Sc. M. E.

Rize — a county of north-eastern Turkey — lays on the south coast of the Black Sea. The country has a very moist and mild climate: it occupies the 17th place in world-rain statistics with 2900 mm/year rainfall, and ripens not only fruits like hazel-nuts, oranges etc., but even such a rare plant as tea may be grown. This climate is due partly to the Pontus mountain-chain parallel to the Black Seacoast, compelling thus the



Panoramic view of Ikizdere power plant

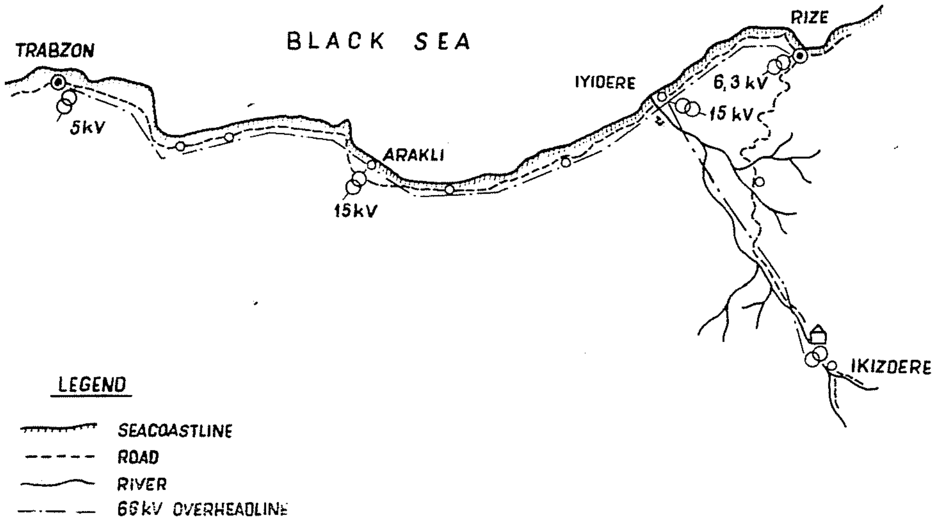


Fig. 1. Sketch of the Ikizdere hydroelectrial system

clouds coming from the sea to drop their moisture still on their northern slope, partly to the Caucasus impeding the Siberian colds in winter.

Though the agricultural richness of the country on account of this favourable climate always had a great economic importance for Turkey, this increased considerably since the introduction of tea growth, begun 20 years ago; it is her great interest to grant the maximum aid for this developing agricultural branche and for the new tea-fermentation industry, as the increase of tea production directly affects the exchange balance. Consequently, the electrification of the country has become an obvious necessity, and it was decided to construct the Rize-Ikizdere hydroelectrical system, consisting of the following: (see figure 1)

A hydroelectrical powerplant of an output of 23 000 HP on the river Ikizdere in the proximity of the village of the same name. A 66 kV transmission line from the power plant to the coast and passing there along the coastline to Rize (countytown) respectively to another greater city: Trabzon (ancient capital of the Roman colony Pontus, important seaport and transittown for Iran nowadays).

Four substations at Iyidere, Rize, Arakli and Trabzon for the distribution of energy to the nearer countryside at lower voltages.

The public adjudication for the execution of this project was announced by the Iller Bankasi — one of the Turkish state investment financing banks — in autumn 1954.

Many firms of international renown submitted their tenders for the adjudication: the Iller Bankasi accepted our offer covering the delivery of turbines, alternators and other electrical equipments manufactured by the Ganz Works, since it was found technically and financially the most favourable.

The contract for projecting, manufacturing, testing, delivery to site, erection and putting into operation for the mechanical-electrical part was concluded on May 17th, 1955. At the same time the Iller Bankasi contracted with the Turkish Kesin Ltd. firm for planning and execution of all civil works.

Immediately after signing the contract technical discussions began with Iller Bankasi resp. with Kesin Ltd. to clear up the exact technical details of the whole system to be constructed and to find the most economical and suitable solutions. The discussions run some months and proved to be very useful since some important changes could be suggested to make the investment more profitable; e. g. it was found that by minimal excess costs the head may be heightened from 156.7 meters to 162.5 meters affording an increase from 7350 HP to 7650 HP in the output of each turbine.

The technical details having been cleared up the final drawings were prepared and submitted to the Iller Bankasi for approval in summer 1956. With some unimportant

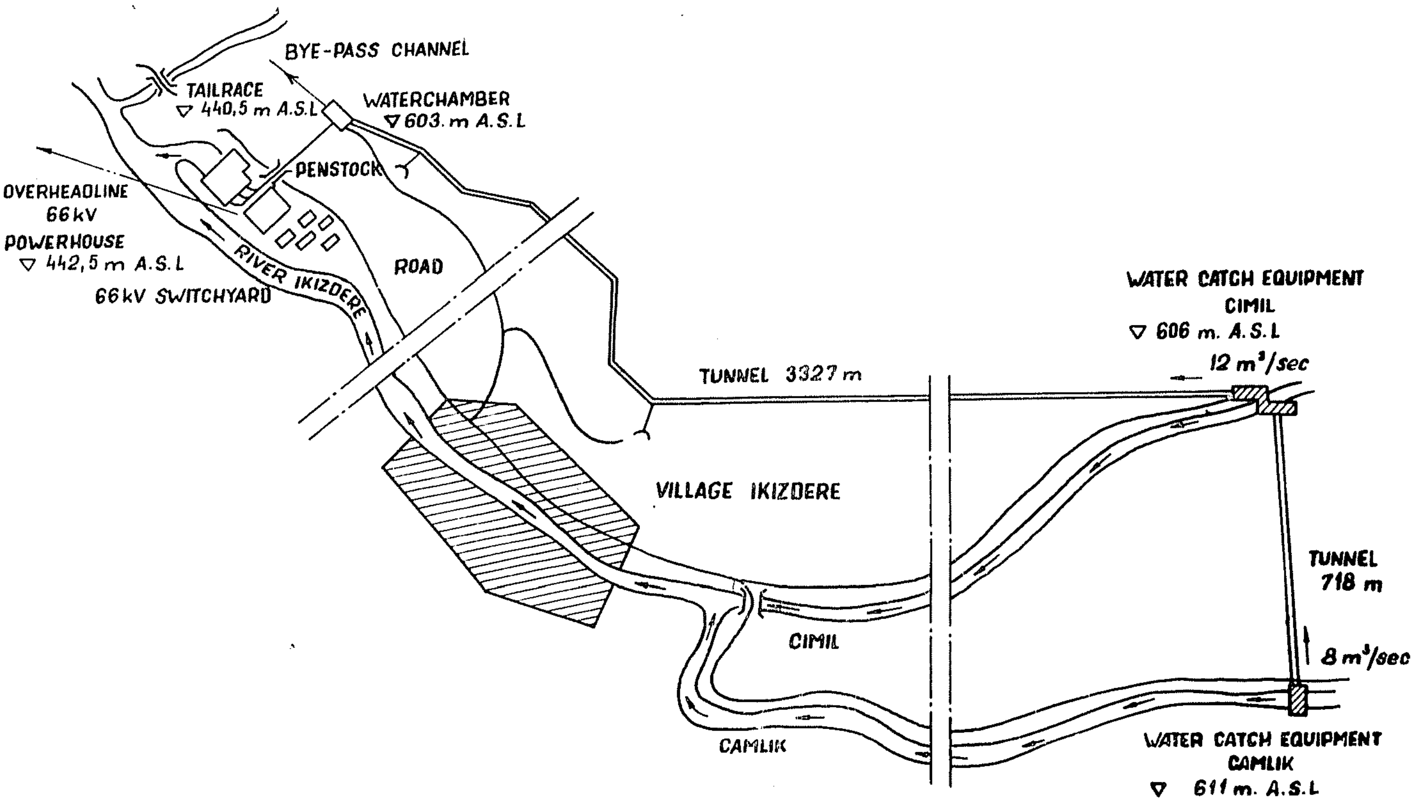


Fig. 2. Layout of the power plant Ikizdere

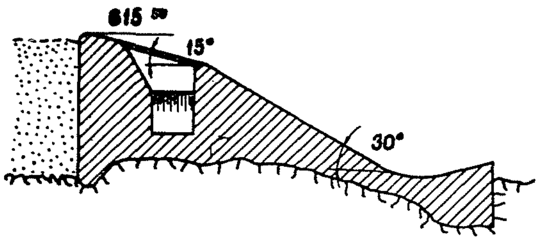


Fig. 3. Water-catch equipment

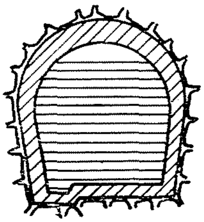


Fig. 4. Cross-section of the tunnel

changes the Bank approved the drawings and both manufacturing of equipments and execution of civil works could begin.

The layout, and technical characteristics of the hydroelectrical system according to the final, approved drawings — as used for erection — are the following:

Layout of the Power Plant

Figure 2 shows the site of the power plant at the Ikizdere river about 2 km from Ikizdere village in waterflow direction. Service water is catched 5 km ahead from the powerhouse from the two riverbranches called "Camlik" and "Cimil". The water abducted from Camlik — 8 m^3/sec — flows through a horizontal tunnel (700 meter) to the water catch equipment of Cimil, is fused to water taken from there — 4 m^3/sec —. The 12 m^3/sec service water available at Cimil flows through a horizontal tunnel of 3300 meter to the water chamber built on the mountainside above the powerhouse, enters there in the single penstock which distributes the water at the powerhouse for the 3 turbines. The service water leaving the turbines enters a short tail race and flows back to the river.

The 66 kV outdoor switchgear is behind the powerhouse. Here starts the 66 kV transmission line along the valley to the seacoast as well as a 6.3 kV transmission line along the road to Ikizdere village to meet the demands of the village consumers.

Five houses were built near the powerhouse for the staff since the village is far and could not offer proper accommodation.

Water catch equipments

Both riverbranches — Cimil and Camlik — have high speed waterflow, attaining at high water 10 m/sec — and roll great amount of precipitates. Taking into consideration these facts as well as the necessity of continuous operation of the power station, a special type was chosen for the water catch equipment (see figure 3): the weir is hollow and is covered by a grid built in with 15° inclination joining the weirback with 30° inclination. Rocks and stones roll away downwards on the surface of the grid; small grained precipitates falling down with the waterflow in the pit are swept away on its steep sloped bottom to a rinsable gathering well.

Settling basins are located between the weir and tunnel inlet. Bye-passes direct overflow water back to the river; regulation of water quantity according to water absorption of the turbines is done by sluices.

Tunnel

The service water tunnel leading water from Camlik to Cimil resp. from Cimil to the waterchamber has a very smooth slope — 3 $^0/_{100}$ — corresponding to friction

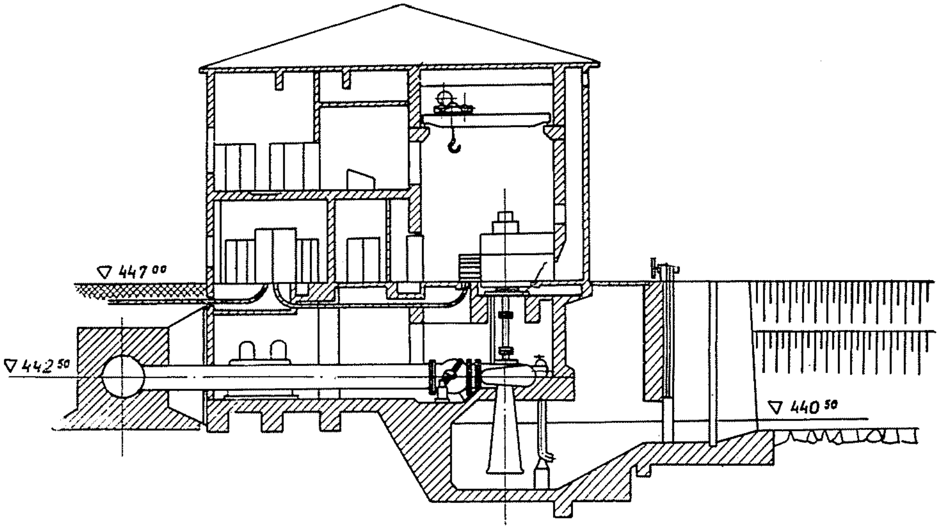


Fig. 5. Powerhouse of Ikizdere

losses. The water does not fill the whole cross section of the tunnel — see figure 4 — and streams like in a channel with an average velocity of 1.9 m/sec at full load.

The tunnel is bored into granite almost in its whole length (to assure this a detour had to be made at one place) resulting a 17 cm thick concrete wall.

The tunnel was built by the Kesin Ltd using two "window" galleries from the side. Thus tunnel boring was simultaneously done at 6 places to shorten working time.

Water chamber

The water chamber, built at the end of the tunnel, directs service water through a grating into the inlet piece of the penstock. A pressure oil operated sluice valve equipment is installed at the inletpipe to close automatically down waterflow if a pipe should be broken. The bye-pass channel starting from the water chamber diverts overflow to a neighbouring uninhabited valley if turbines are loaded off — but service water streaming through the tunnel could not yet be adjusted to the new operating conditions.

Penstock

The single penstock — connecting water chamber with powerhouse 160 and some odd meters below — has a length of 300 meters and an interior diameter of 2100—1900 mm, admitting thus a water velocity of abt. 3.5—4.3 m/sec corresponding to a water consumption of 12 m^3/sec at full load.

The penstock is of the welded design, pipes were manufactured in 6 m lengths with regard to transport difficulties and mounted at side by welding.

Powerplant

As shown in figure 5 the three units of spiral cased vertical shaft Francis-turbines — manufactured by Ganz — are mounted on the basement of the powerhouse. Their main data are the following:

Head:	162.5 meters
Rated output	7650 HP.
Speed:	750 r.p.m.
Runaway speed:	1350 r.p.m.

Water is led to the turbines from the pipes through pressure oil operated spherical valves; having passed through the turbines water flows through a vertical suction pipe to the tail water well and from there to a tail race. The hydro-mechanical part includes the following main parts:

1. 3 water turbines
2. 3 spherical valves and one pressure oil plant
3. 3 pressure regulators for the turbines
4. 3 speed governors and pressure oil plants
5. 2 drainage pumps
6. 3 axial bearings and bearing lubrication devices
7. 3 sluice valves for closing the tail water wells.

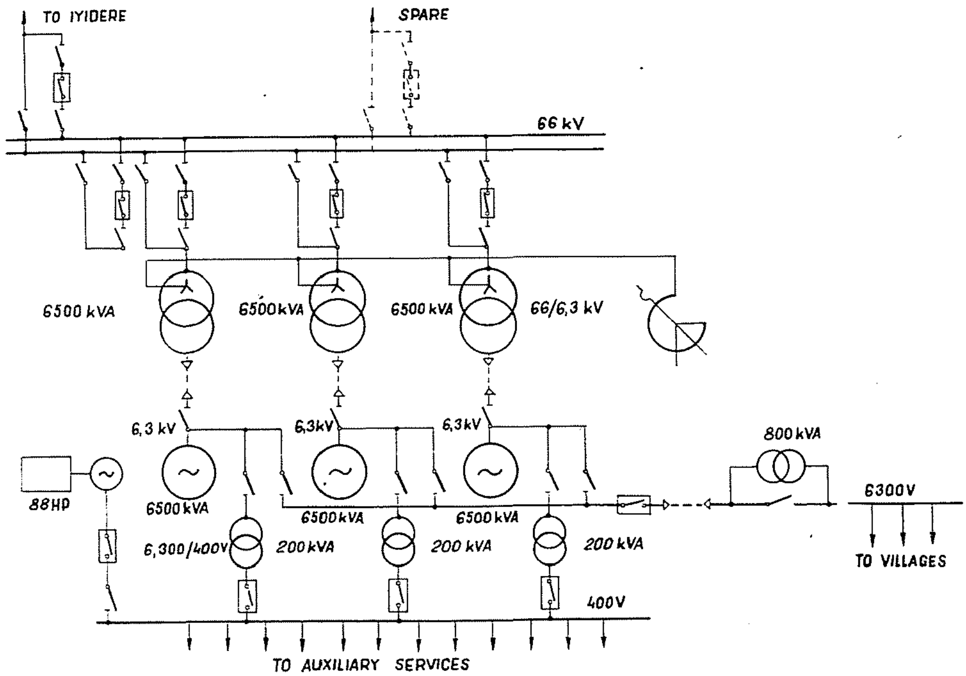


Fig. 6. Powerplant Ikizdere connexion scheme

On the ground level — directly coupled to the turbine-shafts — are the three vertical alternators delivered by our firm, having the following main data:

Cont. rated output	6500 kVA
Power factor	0.8
Rated voltage	6300 V
Speed	750 r.p.m.
Frequency	50 c/s
Number of phases..........	3
Connection	Y
Number of terminals	6

The turbine alternator set is running in three bearings, the axial bearing – carrying the rotor weights (turbine, alternator, main and pilot exciter) and the hydraulical charge — is mounted on beams supported by the stator. The alternator is of the closed design, fresh air cooled, self ventilating. The rotor of the pendulum-driving generator is mounted on the shaft's end above the pilot exciter.

We also delivered for the machine room a crane with a lifting capacity of 20 tons, an auxiliary Diesel group of 88 HP, a switch and control board (for the remote control of the machine units) installed in the machine room in front of the alternators. In the part of the building which adjoins the machine room are located the electrical equipments, offices, stores and a workshop.

As shown in fig. 6, the alternators are unit connected to the 6500 kVA 6.3/66 kV outdoor step-up transformers supplying through circuit breakers the 66 kV common bus bar system, consisting of a main and a bye-pass bus bar. For the time being there is only one 66 kV overhead line to Iyidere but a spare field is provided for later extension. Transformers and overhead line may be connected to the main bus bar either by their own circuit breakers or — in case of failure or maintenance — by the coupling field circuit breaker and the bye-pass bus bar. The 66 kV switchgear is outdoors, beside the powerhouse. The 66 kV circuit breakers are of the small oil volume type actuated by remote controlled D. C. motors. Transformers are oil immersed, natural air cooled. The three 6.3 kV overhead lines — supplying energy to villages in the neighbourhood — are fed through a 800 kVA 6300/6300 V insulating transformer to prevent direct metallic contact between alternators and network; the primary side of the transformer may be connected to whichever of the alternators but naturally only to one on account of the unit connexion scheme. The auxiliary transformers of 6300/400/231 V, also unit

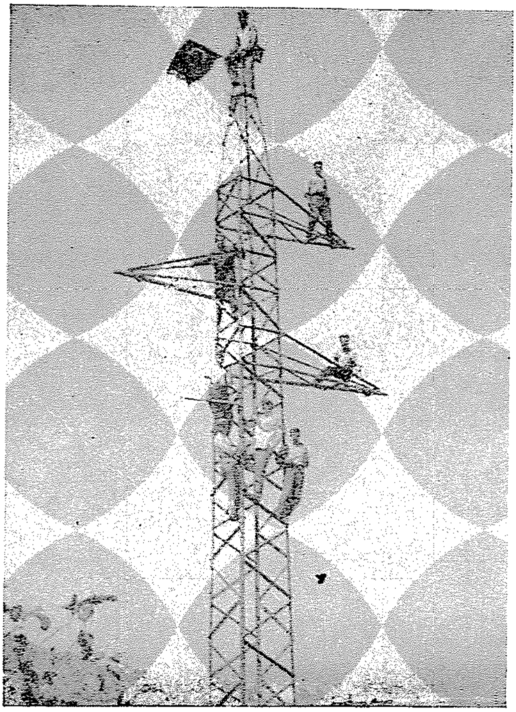


Fig. 7. Erection of steel-lattice towers (in the rear the port of Trabzon)

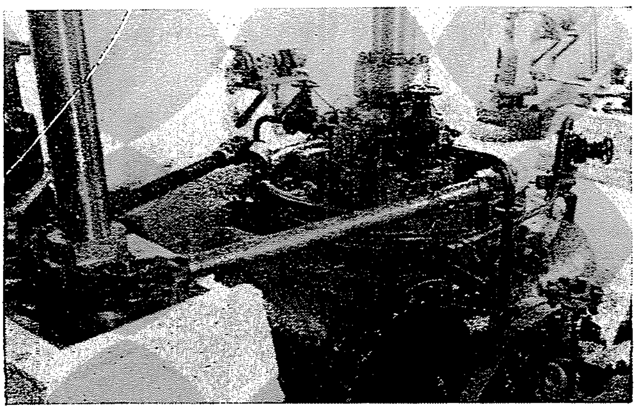


Fig. 8. Mounting of the Francis-turbines

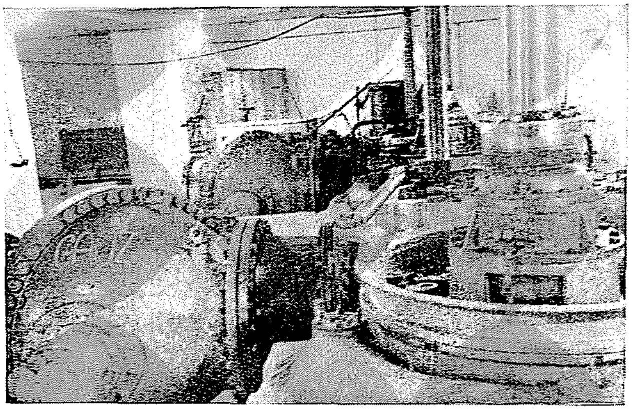


Fig. 9. Turbine-level of the powerhouse

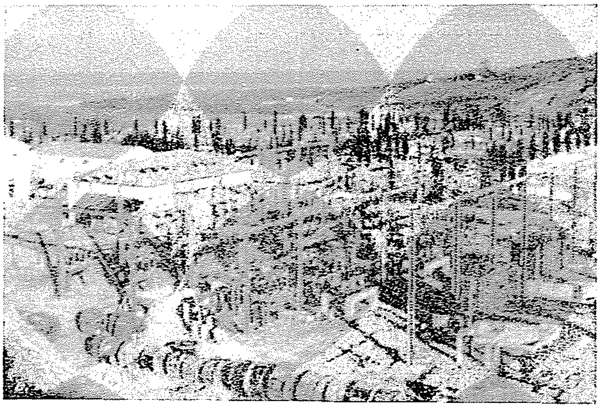


Fig. 10. Substation of Trabzon

connected to the alternators, feed the common 400 V bus bar to which are connected the auxiliary services as well, as the motor-generator set and the mercury vapour rectifier — both for charging the 220 V lead accumulator battery. The Diesel set serving for starting purposes at complete breakdowns is connected to the auxiliary bus bars too. The 6.3 kV switchgear and auxiliary service switch board are of the metal clad type, located indoors, on the ground level of the powerhouse. The 6.3 kV overhead line switch board is also metal clad but placed outdoors, beside the 66 kV switchgear.

For the protection of the alternator-transformer units the following protective systems are provided:

Overcurrent protection, Differential protection, Overload protection, Earth leakage protection, Voltage increase protection, Buchholtz relays for the transformers. High tension fuses provide for protection on the 6300 V side of the auxiliary transformers, which are protected on their 400 V side by circuit breakers.

The overhead lines are protected against overcurrents, earth leakages and by lightning arresters against overvoltages.

The relays of the protecting system, the instruments, signalling devices and the actuating switches for remote control are built in the control panels and in the control table — both metal clad types — located in the control room placed on the first floor of the

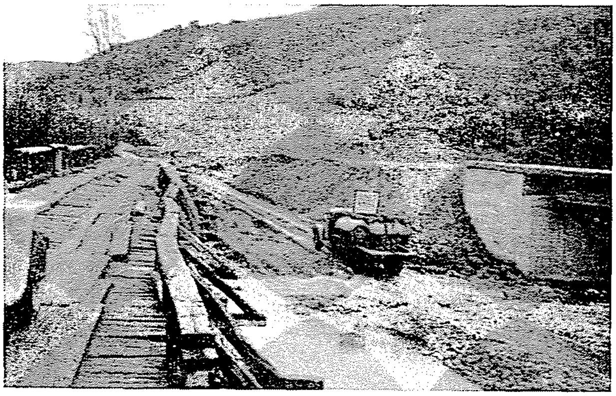


Fig. 11. Lorries transporting heavy pieces had to cross riverbeds since bridges were not proper

powerhouse. In the same room is the metal clad control panel of domestic services i.e. of electrical auxiliary applyances such as heating, lighting accumulator battery etc.

A high frequency telephon equipment for communicating with the substations and connected to the domestic telephon system is also installed on the first floor.

The whole electrical equipment of the powerplant — manufactured by the Ganz works — was delivered by our firm.

66 kV Overhead line

The overhead line built between Ikizdere and the seacoast following the river-valley resp. between Rize and Trabzon along the coastline has a total length of 105 km. The pegging out of the line was not an easy problem, since the river-valley is very narrow and deep — almost canyon like — bordered by high mountains which are covered with dense forests and the line had to be located as near as possible to the road passing in the bottom of the valley considering the erection and maintenance. The coast line area is not much easier either, because the steep mountain slopes extend to the coast. In spite of this unfavourable ground conditions our surveyors succeeded to keep low the number of angle-points and by this means to improve the economy of the overhead line.

There are altogether 417 steel lattice towers along the line with an average span of 270 meters. Intermediate masts are one-legged, strain towers mostly four-legged depending from ground conditions; some special towers are erected for longs spans — amounting to 600 meters — over valleys.

The masts have concrete bases; conductors are arranged in delta and hold by steel lattice cross arms, earthwire being on the top of the mast.

The steel-aluminium type conductors have a cross section of 150/181 mm^2, the steel earthwire has a cross section of 50 mm^2.

Insulator chains comprise 4 insulators of the cap type, straining chains being built of the normal chains.

On every line-section between substations three phase-transpositions are provided. Insulators, conductors, earthwires and steel towers were delivered by our firm, the latter in prefabricated pieces to be mounted at site by screws considering transport difficulties on the erection area.

Substations

The electrical equipments of the substations delivered by our firm are similar both in arrangement and in execution to that of the powerplant. The 66 kV switchgears are of the outdoor type, having a main and a bye-pass bus bars, small oil volume circuit breakers, oil-immersed natural air-cooled transformers. The secondary tension switchgear is of the metal clad type, located in the control building. The auxiliary service transformers supplying energy to the 400 V bus bars are placed indoors. Measuring instruments, relays, signal and remote control devices are built in the metal clad control panels which are placed together with the domestic service switchboard indoors in the control room. Every substation is provided with a lead accumulator battery and a mercury vapour rectifier.

Iyidere substation — situated at the mounth of the river Ikizdere — has one incoming

Fig. 12. Sharp curves caused problems for long pipes

Fig. 13. Transport of transformers through the mountains

line from Ikizdere and two outgoing lines to Rize resp. Arakli. One 1000 kVA 66/15 kV transformer is provided but there is spare field for later extension. There are three lines on the 15 kV side for the villages Iyidere and Karadere and a spare.

Rize substation — situated in the county-town of Rize — has an incoming line from Iyidere and a spare field (not built-out) on the 66 kV side. Two 2000 kVA 66/6.3 kV transformers are installed and there is a spare field for a later third one. The sub-

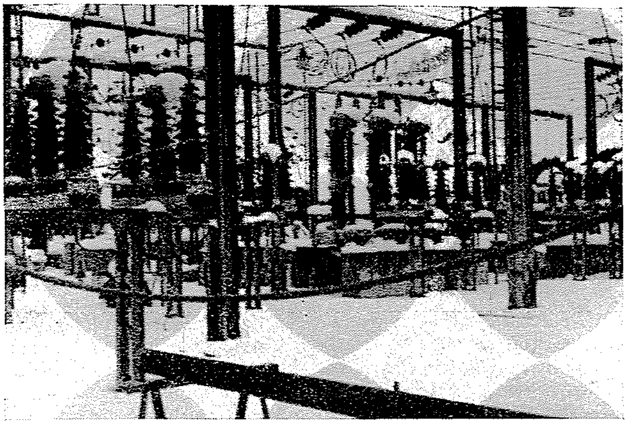


Fig. 14. A 66 kV outdoor switchyard after a heavy snowstorm in February 1959

Fig. 15. Floods destroyed many a bridges on the road to Ikizdere in May 1959

station has 6 branchings on 6.3 kV to the town and to the tea-fermentation factory.

Arakli substation — situated on the seacoast between Iyridere and Trabzon — has an incoming line from Iyidere and an outgoing one to Trabzon on the 66 kV side. One 1000 kVA 66/15 kV transformer is installed; the substation supplies energy on 15 kV to the neighbouring villages on the seacoast.

Trabzon substation — situated in the town of Trabzon — has two incoming lines on the 66 kV side: one from Arakli and one from a projected power plant. Two 6500 kVA 66/15 kV transformers are installed; the substation supplies energy to the town on 5 kV with 6 branchings.

*

Manufacture of the hydromechanical-electrical equipments at the Ganz Works in Budapest was inspected by engineer experts of the Iller Bankasi and tests were made according to DIN and VDE standards. The tests having successfully been carried, deliveries began in 1957 and lasted till spring 1959 on account of the fact that proper storerooms at site were not available and only that sort of material could be delivered which either was of the outdoor type or could be placed in the finished buildings.

The port of destination was Trabzon — in Rize there neither is pier nor are adequate cranes — and custom formalities were made there too. It is to be mentioned that custom laws are very intricate in Turkey, and achieving custom formalities was sometimes a very difficult matter for us, since the many kinds of material delivered for the power plant confronted even the Turkish custom-officers in Trabzon with new problems. Goods were delivered from Trabzon by lorries to the site and this transport was one of our greatest difficulties.

The 90 km road from Trabzon to Rize along the coastline is of a middle quality and apart from some narrow places and some secondrate bridges did not mean serious problems.

More serious difficulties rose the road from Rize to Ikizdere (60 km). It passes through high mountains, climbs and descends twice from almost sealevel to 1000 m heights and reaches the river-valley 25 km before Ikizdere following there the river at the bottom of a very narrow valley. There are 134 smaller and bigger bridges on this road and it has a section of 6 km where it winds in 66 hair-pin curves. The very narrow road is cut almost in its whole length in the mountainside resulting deep precipices at one side and steep — wall like — slopes on the other. Water streaming from the mountain falls on the road at some places, rocks roll from the height and soilslides happen quite often.

Under such circumstances transport of material from Trabzon to Ikizdere was really not an easy matter especially those of the heavy pieces weighing more than 10 tons; lorries had sometimes to cross riverbeds (see fig.) and transport of alternators and transformers had to wait for the end of 1958 till 34 bridges were reinforced by the Turkish roadbuilding office in order to make possible passage of the trayler weighing 35 tons with the load.

Pace of advancement of civil works determined beginning of the erection works, which started in summer 1958 at the substation of Trabzon prepared the first. Later — during autumn — buildings and outdoor concrete bases at Arakli and Iyidere as well as turbine level of the powerhouse were given to erection and mounting could continue on a larger scale. The rest of the powerhouse and civil parts of the switchyard in Ikizdere were ready in spring of 1959 whereas civil works at the substation of Rize were finished only in summer.

It also has to be stated that the pace of civil works is wholly motivated by amount of soil-excavation works having been done in a much greater scale than originally counted for, since it was not possible at most cases to choose a plain ground for buildings and switchyards.

The erection work required a considerable investment from ourt part; auxiliary Diesel groups had to be installed at the power plant and at the substations to supply the necessary electrical energy: lodgings and stores had to be built since proper accomodation and storerooms were not available. For the erection of the pen-stock a funicular railway had to be built on the steep mountainside. All tools, measuring instruments, machines (drilling machines, turning lathes, ets.) for the mounting work had to be provided by us from our works as well as materials needed for assembly at site such as electrodes, carbide, paints, since none of them was available on the market. Even fuel and oxygen supply met sometimes difficulties, as fuel could be procured only every third-fourth week and oxygen tubes had to be sent to Istanbul — 1200 km afar — to be refilled. It can be said without exaggeration that erection work was a pioneerwork on a hard terrain.

Our erection work was seriously hampered by calamities and misfortunes. In February of 1959 a formidable — since ages non observed — snowstorm swept over the country tearing up trees by the rootes and closing roads with snowdrifts for many a days even on the seacoast. The snowstorm damaged the outdoor equipments being mounted and destroyed some of our workshops.

Heavy rains followed during spring and soil was moistened in such a way that landslides on the Rize-Ikizdere road happened almost daily, cutting away Ikizdere from the other erection areas and from the supply three-four days in a week.

In May — at the beginning of snowthawing in the mountains — the continuous rains resulted in disastrous floods in the country, inundating villages and roads, demolishing houses and bridges. The flood of Ikizdere river swept away important hydromechanical equipments (f. i. still non mounted pipes), damaged others, and destroyed the road in a lengts of 20 km to such a degree that for two months the power plant was only accessible afoot.

The erection work is now finished except the destroyed part of the penstock, — and putting into operation after the penstock mounted will depend only on availability of service water, i. e. from finishing the concrete wall refilling works of the tunnel. Very likely at the end of this year everything will be ready and Ikizdere, the fifth largest hydraulical powerplant of Turkey, will supply energy to the country.

SHORT REVIEW OF THE UP-TO-DATE MECHANIZED SMALL SLAUGHTER-HOUSE

By

A. Gaál

The erection of provincial slaughter-houses which were to provide the smaller towns used to be rather expensive both as far as machinery equipment and architecture are concerned.

In old days the towns consented to investments of the kind only after due consideration and merely when it could be helped to improve local sanitary conditions.

Due to the investment costs it was absolutely necessary to find new ways so as to combine the reduction of the maintenance, architectural and processing costs with the most up to date, mechanized slaughtering technology by strict observance of the most extensive hygienic requirements and the increasing level of mechanization.

As a result of our studies we have realized that it would be advisable to initiate a combined method of slaughtering as far as smaller slaughter-houses are concerned where different species of animals (cattle, calves, sheep, pigs) can be slaughtered on the same line but not at the same time.

After the sanitary authorities had scrutinized our idea they found there being no hygienical obstacle in the way of such a solution.

Having consulted relevant statistics we could decide upon the most suitable capacity for a slaughter-house that would meet our conditions and, as a result we started developing a slaughter-house fit for slaughtering 30 pieces of cattle or 60 pigs or 120 sheep hourly by employing the same number of manpower.

Thus there was a possibility to stabilize the working process even subject to the record slaughtering figures appearing per species of animals at different periods, according to the season.

Instead of the two halls which usually could not be exploited at the same time entirely only one hall is to be built, the maintenance, heating, lighting of which is much cheaper and the production falling to a certain unit of the basic area would increase considerably.

As against the practice applied hitherto by having installed the machines in both halls, our idea is to carry out the mechanization at a higher level than ever, which simplifies, speeds up and renders slaughtering more hygienic — on one place where the same machines can be utilized for the most part.

This way the investment of machinery can be considerably reduced whereas the rate of its exploiting shows an upward tendency, resulting at the same time in a greater uniformity of the necessary expenditure. The use of manpower is rendered more economical by the right choice of the working-stages and places.

The working efficiency of the combined slaughtering-lines may be enhanced to a certain degree by augmenting the number of working places and the length of the line starts from two points such as the place for stunning the cattle and the one for stunning the pigs. These two lines converge before the sticking process only to diverge again when scalding and skinning the pigs.

Hereupon the two lines converge for the following phases of the preparation.

Slaughtering of cattle :

Narcotization is carried out by means of electricity in boxes. After having tied the feet of the cattle with chains the body is lifted from a horizontal position by means of an automaton and is placed automatically on a high-track of sheet-iron. A conveyor band carries the animal to the sticking place where it is stuck after being hung up and passes along the bleeding-line. Hereupon the head is skinned out and removed.

The horns are removed with a special horn-saw.

The headless cattle having been conveyed to the hungover place the tendon of Achilles is opened and the skin is cut up. Then trolleys are inserted into the opened tendons of Achilles and the animal is being let down onto the lower-lying processing line. This way the animal lying on the bleeding roller, gets to the processing line with rollers clamped in each of the Achilles tendons. The chain roller to be used for bleeding, rolls back to the narcotization box.

The next operation is the preliminary skinning to be carried out in a workmanlike way only if the hind legs pushed by the conveyor are adequately stretched. For this reason the hind legs of the animal pushed on the conveyor are stretched by an automatic legstretcher, controlled by the conveyor and are pushed along the path accordingly. The elevated path provided with a conveyor passes in front of platforms of different levels and the carcasses are lying by prone on it.

In regions where animals of relatively the same size are processed 3 or 4 platforms are fixed at different heights. However, where animals vary in sizes the working platforms are operated hydraulically.

On the first, highest platform the hind legs are skinned out and removed whereas the flank and the forefeet undergo the same procedure on the other platforms. Approximately $20^0/_0$ of the skin is pre-skinned. The animal pre-skinned this way is conveyed to the skin-husking machine standing on the by-pass.

The forefeet of the animal are fixed before the husking machine. There the chain is braced on both sides around the shoulders-blades. The bracing-chain is hung into hook of the endless chain of the husking machine. This chain husks the skin by and large towards the muscles which are on the surface of the body. This chain, mounts on a parabolic path. This is the way to avoid tearing of the skin-surface.

The husking speed depends on the state of nutrition of the animal and therefore the operator may regulate the chain continuously within ample limits during husking. The husking-machine prevents to cut into and through the skin and thus we can protect the quality of the skin besides speeding up the work.

At cattle-slaughtering lines of a higher output the mechanical husking of the skin may be performed continuously.

The skin is conveyed by the husking-machine into a slidway transporting it to the skin-storage room and into its preparatory shop respectively.

Then the breast-bone is opened by an electrically-driven saw. The animal is pushed on to the end of the by-path wherefrom the conveyor transports it for eviscerating.

Here the path runs for some meters parallel with the synchronous table. While standing on the table the labouror rips open the flank, takes out the intestines, the rumen, and the spleen which fall on the table and then he removes the harslet, the liver, the lungs and the heart. These edibles are subsequently hung on the sliding row of hooks at the other side of the table.

Having finished this the operator goes over to the other side of the table.

The path turns off from the table in order to allow the performance of the subsequent manipulation, i. e. to split the animals along the vertebral column into two pieces by means of an electrically driven rip saw.

During this time the operator is standing on a working platform, hydraulically moved upwards and downwards. The speed of the downwards moving platform can be controlled by a push-botton placed on the handle of the saw whereas in its way up, — moving with all speed, it is operated by a pedal.

The forthcoming operation is the veterinary examination, during which the rumen and intestines, arriving on the table, reach the harslets rolling on the hook-row, as a result of the synchronous speed of the carcass on the path. In the meantime the examination of the harslets can also be performed.

In dubious cases the two veterinaries, standing in one line at a distance of only 2—3 meters from each other, can exchange their views. In case the harslets or any other part is deemed to be confiscated, the trimmings or, possibly the entire harslet falls into the slip-way. However, if the meat itself should be confiscated, the veterinary will direct the confiscated carcass to a by-pass. The sound edibles automatically fall off the hook onto a tray on a car, to be conveyed to the cooling store.

The rumen is delivered by means of pliers to the tripe-processing shop. The intestines fall straight into a car and get to the competent processing-shop.

The by-products transported for treatment to some other place are numbered and can be traced in case of confiscation.

In the course of further processing-work the labourors, standing on operation-platforms of various levels cut out the kidney, the fat and the bloody meat, the unnecessary thin skins and wash the half carcasses.

After being weighed and cut into halves or quarters they get into the subway for quick speed-freezing from where it is conveyed to the holding-cooler or to the freezing equipment for delivery.

After being bled the carcass remains on one and the same trolley until delivery.

In case of smaller slaughter-houses — and this is the present case — the animals are quartered in the slaughterhall with the intention of exploiting the quick-precooling equipment, to secure the right streaming of the cooling air, to save building costs and path-supports (the thin sheet-iron paths are directly fixed to the concrete ceiling) After separation the electrical lifter places the first quarters automatically on the path.

If necessary, the quartering can also be performed after refrigeration.

The figure shows the slaughtering-line of cattle in one of our shops, the building of which had only been provided with the necessary mechanization by us. The thick lines are to mark the generally used cattle-slaughtering line.

Slaughtering of pigs

As to the slaughtering of pigs the following three methods of procedure are to be distinguished:

a) Slaughtering by scalding (the method in general use).

b) Skinning to the crop skin.

c) Complete skinning with the exception of head and feet.

The routine procedure in Hungary is slaughtering by scalding the skin or complete flaying. The processing line has been established accordingly.

After narcotization to be performed either electrically or by the gas CO_2 one leg of the pig is provided with a trolley to carry the pig to a sloping-elevator. This lifts the pig and forwards it to the sticking place, where it is stuck by labourors standing on a high platform. After the bleeding the path branches off through points.

The scalded, skinned pig is rolled to the hopper in order to be conveyed to the scalding-vat.

After being scalded the automatically-operated horizontal dehairer lifts the pig out of the scalding-vat for dehairing and throws it on a re-cleaning table, placed on the other side. Here the tendons of Achilles are provided with stretch-hooks and are lifted on to the path. This is the point where the pig and cattle-line are united. Conveyors transport the pigs along the path.

The skin is cleaned on the line designed for pre-skinning. It is provided with automatically-operated showers.

In case the main principle should be to prepare bacon or ham, a singing furnace and a black-scraper may be installed in the part before the conveyor. After the breastbone is split the carcass is cut up and the viscera are removed in the same way as in case of cattles. The splitting into two parts of the pig is done by means of the same electrical rip-saw from the hydraulically-operated platform moving up and down. It goes without saying that the saw-blades are changed according to what kind of an animal is processed.

The further phases of the processing works mark the veterinary examination, the removal of the leaf-lard and the kidneys, further on cleaning and washing.

After being weighed the pigs are conveyed to the quick-precooling store.

In case of skinning after bleeding the head of the suspended and stuck pig is scalded in the following way:

The animal is pushed above a hydraulically-operated scalding var which is lifted into the required height. The next process is to convey the animal to the hydraulically-operated head-shaving machine.

Henceforth, the animal is conveyed to the previously-mentioned scalding-vat which is filled up with water of 38—40° C. The dirt on the bristles is softened by water and is removed in the dehairer.

From the re-cleaning table the animal is put on to the pre-skinning conveyer where $10^0/_0$ of the skin is pre-skinned. The whole skin is removed on the horizontal skinning-machine.

After the skinning process the pig is put on the path. The subsequent process has been previously described.

Slaughtering of sheep

Similar to the slaughtering of pigs, it is the pig-elevator which lifts the sheep to convey them to the stubbing and bleeding path. However, the animals are hung over on the cattle-line for being processed.

When slaughtering sheep, similarly to the cattle-line, only pre-skinning machines and continuously-operating skinning machines are employed.

The speed of the conveyor may be adjusted by infinitely variable speed-regulation with an electric motor, in accordance with the species of animals and the number of staff. The possibility of moving synchronously with the table is secured by an electrical axle.

The viscera hanging on the hook will be cut up and will be defecated in the most hygienic way.

The contents of the rumen falls into a tray in order to be moistened and to be forwarded by air-pressure into a drip-tube situated at a remote place of the plant, wherefrom it is dropped into a conveyor.

The defecated viscera is washed in a

centrifuge, and after being scalded, cleaned in an abrasive centrifuge and edged, it is conveyed to the refrigerator.

After having cleaned the intestines in the respective processing shop on a machine-row they are salted or dried.

The economic efficiency of the slaughter-house which has been erected along the above principals registers a 30% rise of productivity. The staff and the overhead-expenses could be cut, and hard physical work has been eliminated, accordingly.

Energy-consumption could be rendered more equal and the exploitation of the machinery could be increased by 60%.

As result of an improved harnessing and the manifold exploitation of the machines the investment costs register a 30% decrease in respect of the entire establishment.

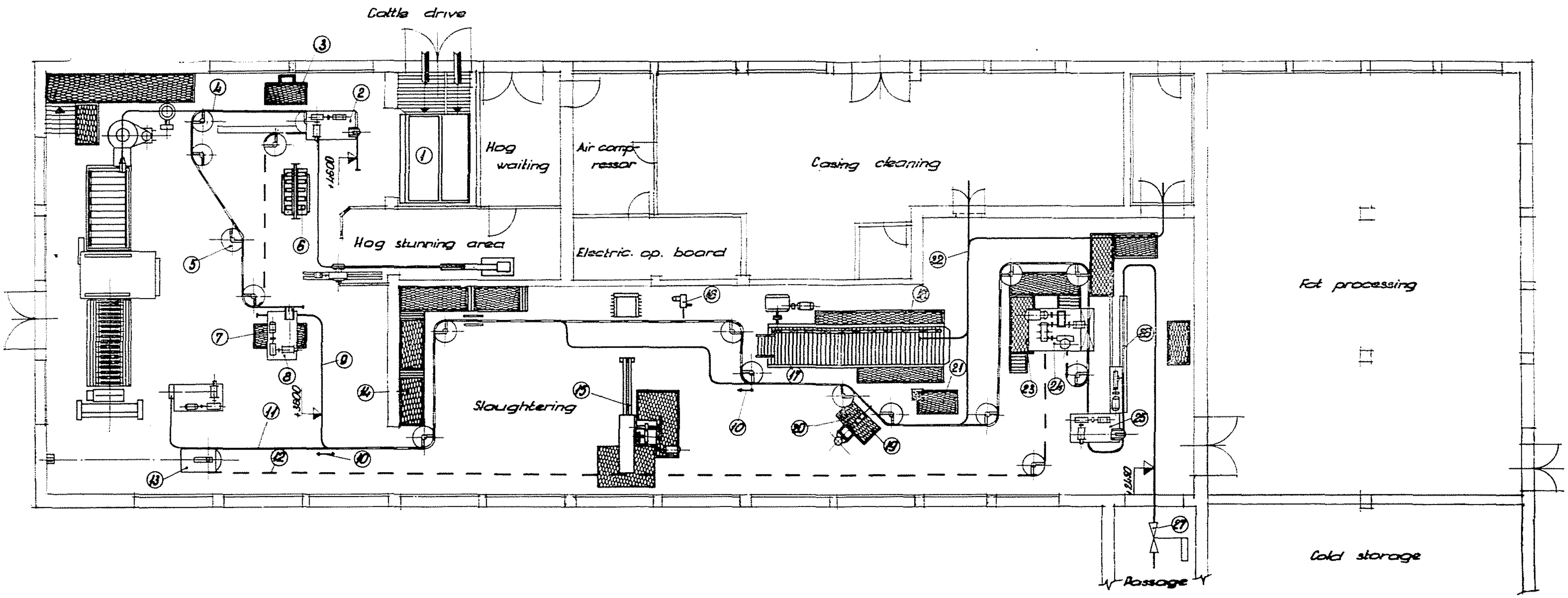


Fig. 1. Slaughter-house for 30 cattle/hour or 60 hog/hour or 120 sheep/hour. Cattle slaughtering 1 : 100

1st illustration

1. Automatic cattle knocking pen with stunning equipment.
2. Electric beef hoist with automatic beef lander for hoisting stunned cattle from knocking pen to bleeding rail.
3. Hydraulic operated elevating platform for sticking.
4. Conveyor driven bleeding rail.
5. Conveyor idlers.
6. Head inspection truck.
7. Work platform for cattle transfer from blooding rail to dressing rail.
8. Electric cattle transfer equipment.
9. Flat rail for overhead tracking.
10. Automatic cattle hind leg stretching equipment.
11. Dressing and operating rail with conveyor drive.
12. Conveyor return.
13. Conveyor take up.
14. Work platform for preskinning.
15. Cattle hide puller machine.
16. Electric brisket saw.
17. Viscera operating and inspection table.
18. Intestine conveyor.
19. Electric carcase saw.
20. Hydraulic operated elevating platform.
21. Inspecting platform for veterinary.
22. Overhead tracking for tripes.
23. Work platforms for lard and kidney cut out.
24. Electrically-controlled synchronized conveyor drive.
25. Equipment for cattle quartering.
26. Lowering conveyor from dressing rail to cooling rail.
27. Overhead track scale.

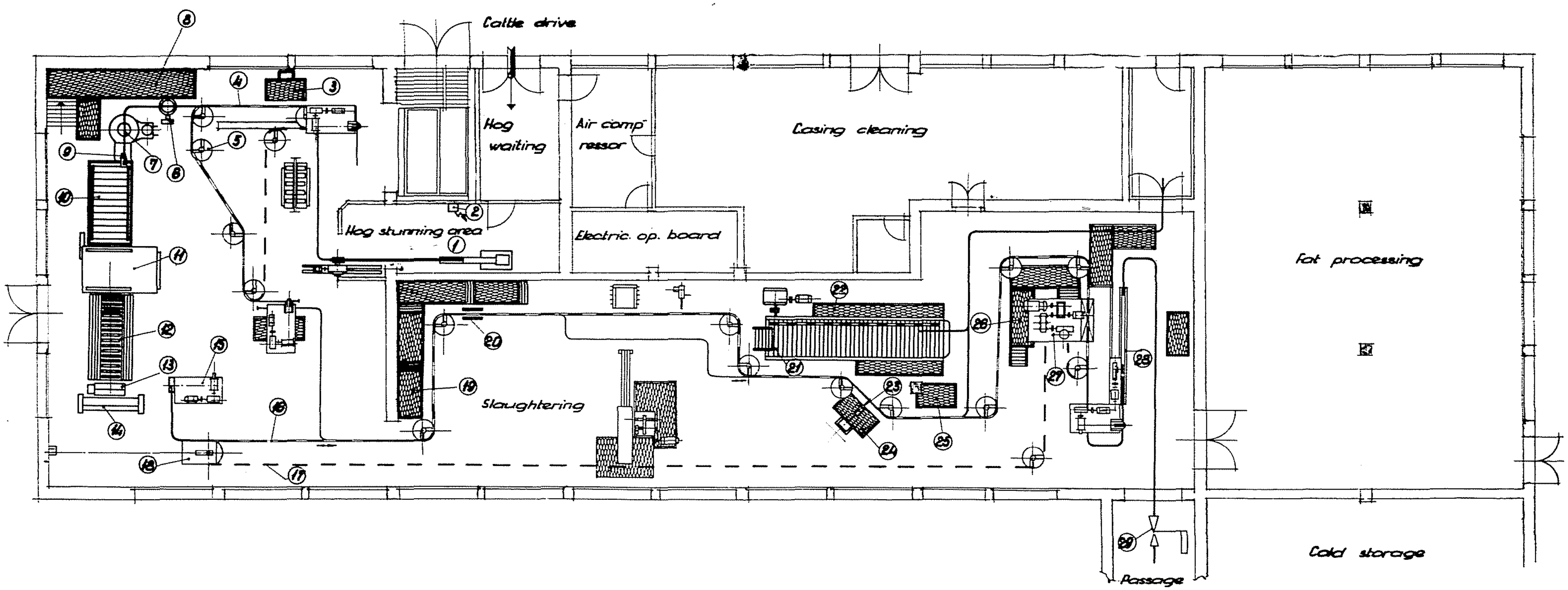


Fig. 2. Slaughter-house for 30 cattle/hour or 60 hog/hour or sheep/hour. Hog slaughtering 1 : 100

2nd illustration

1. Hog hoist.
2. Electric stunning equipment.
3. Hydraulic-operated work platform for sticking.
4. Bleeding rail with conveyor drive.
5. Conveyor idlers.
6. Hydraulic operated hog head scalding tub.
7. Hydraulic operated hog head dehairer.
8. Work platform.
9. Vertical hog dropper.
10. Hog scalding tub with conveyor drive.
11. Hog dehairer.
12. Hog-cleaning scraping table.
13. Truck for preskinning.
14. Horizontal bog-skinning machine.
15. Vertical hog hoist.
16. Operating rail with conveyor drive.
17. Conveyor return.
18. Conveyor take up.
19. Work platforms.
20. Hog shower.
21. Viscera operating and inspection table.
22. Intestine conveyor.
23. Electric carcass saw.
24. Hydraulic-operated work platform.
25. Inspecting platform for veterinary.
26. Work platforms for lard and kidney cut out.
27. Electrically-controlled synchronized conveyor drive.
28. Lowering-conveyor from operating rail to cooling rail.
29. Overhead track scale.