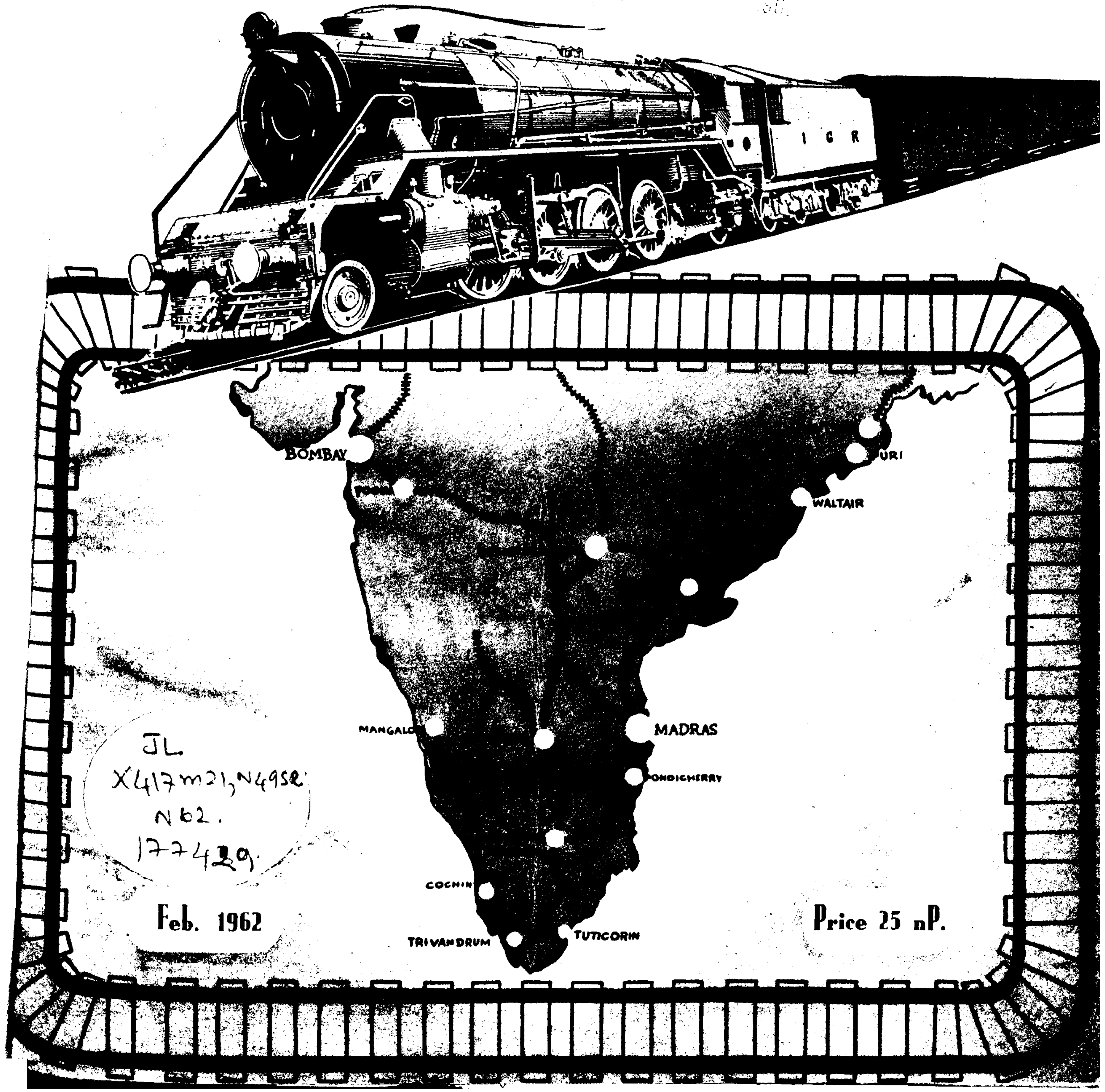
SOUTHERN RAILWAYS *Magazine*



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GOLDEN RULES OF CONDUCT FOR RAILWAYMEN

1. Do you plan your work daily? Get the more essential things done first and do not neglect the important ones sidetracting them to the fag end of the day.

2. Do not express casually careless opinion. Never venture forth an opinion unless asked for it.

3. Remember that most of our mental worries come either from trying to fight life hard or from trying to run away from life. Do neither.

4. Learn to accept people as they are, love them, respect them, praise them, encourage them, differ with them, but above all, learn the priceless art of give and take.

5. Cry neither for the moon, nor over spilt milk.

6. Accept the things that you cannot change; have the courage to change the things that you can, and possess the wisdom to know the difference.

7. Do not drive too hard a bargain with yourself.

8. Accept life as it is — its wonders, changes, disappointments, frustrations etc., etc.

Signalling Cables with a view to Application of Modern Insulation and Sheath and also in connection with A. C. Electrification

BY D. W. CHILIAN *

Mr. Chairman, Members and Guests,

I HAVE been invited by the Hon. Secretary to hold another talk before this Society on a subject to be chosen by myself. Naturally, there are many interesting subjects in Railway signalling and Telecommunication about which one could talk. Some, as for instance, Route Relay Interlocking have already featured very prominently.

I hope you will forgive me if I have selected, as a subject this afternoon, again Railway Signalling Cables. I would, however, not like to deal with this subject only in a general way, as you may have seen already from the title of my talk having been published in the invitation to the today's meeting of the Society.

My talk this afternoon shall cover two interesting aspects of Railway Signalling Cables, namely:

(a) Application of Modern Insulation and Sheath, and

(b) Problems and built-up of such cables in connection with A. C. Railway Electrification.

Both parts of my talk are in a way interlinked and may be considered forming a continuation of Mr. Reddi's talk on P.V.C. Cables before the Society during last year.

Coming now to the first part of my subject, I must review in short the fundamental requirements applicable to cables used in Railway Signalling. Fundamentally, these requirements are very similar to those of low-voltage power cables, because as far as even electric signalling goes today in practice and with few exceptions, voltages to be transmitted usually range between 0—400 volts only, which as far as the practice goes in this country, are even limited to maximum 110—120 volts only. Similarly currents are usually in the range of Mili-amperes only and only in few cases for operation of electro-mechanical devices, as e. g. Point and Signal Machines, may be as high as 10 amps only. The third factor to be considered is frequency, which is either zero, i. e. direct current or commercial frequency of 50 c/s or at the maximum, some slightly higher frequency adopted in areas of A. C. Electrification, being either 83.1/3 cycles, 100 or even 125 c/s for operation of track circuits.

I purposely have omitted in this consideration transmission of coded impulses, telephony, carrier frequency and certain audio-frequencies being used nowadays in C.T.C., Automatic Train Control (= A.T.C.), Tokenless Block working and last, but not least, Electronic Track Circuits. The reason is that these circuits, although used in signalling, rather fall under telecommunication in their study. Further, as the percentage of such circuits at least in this country, compared to other signalling circuits, is negligible, and in most of the cases require other than ordinary signalling cables, the same are not taken into consideration here.

The mechanical and electrical requirements of signalling cables apart from range and frequencies of currents, which I have already stated, can be summed up as follows:

1. Weight, which is a factor to be considered for the easy laying and transport of cables before installation.

2. Tensile strength, which is important for mechanical stability in handling and also to protect the cable under service conditions against stresses, impacts, vibrations and even in accidents.

3. Elongation, which is responsible for the flexibility of cables, (where such is required), but at least to be sufficient for safe and easy laying of cables under normal circumstances.

4. Water Absorption and also resistivity against other atmospheric influences such as high temperature, sunrays, freezing, chemical agents, etc., which again is decisive for the life of the cable or the aging, i.e. the time the cable maintaining its electrical and mechanical properties required for a safe working under the circumstances prevailing.

5. Dielectric strength, which guarantees a safe working of the cable for the rated or working voltage to which it is applied.

6. Volume Resistivity, which determines the insulation properties of conductors and whether such will remain within prescribed limits for the required safe working of signalling circuits over extended periods within the life of the cable.

7. Relative Dielectric Constant, called 'ε' which determines the capacitance of conductors in connection with the applied insulation thickness and built-up of cable, and which must be in line with the requirements for signalling cable, which however, with conventional electric signalling, is not very critical and has only certain importance in A.C. circuits.

8. Dissipation Factor, which is also called 'tan δ' and which determines electric losses of the insulation in A.C. circuits. This also has no practical importance in conventional signalling circuits, although it becomes a decisive factor for determining the attenuation in all telecommunication circuits.

9. Temperature Range for laying and operation of cables. Contrary to power cables, which often are assessed, as per current capacity, signalling cables are hardly loaded to full current capacity, and conductor sizes are determined rather by permissible voltage drop. As such, temperature range does not refer to heating of cable, by current from inside, but instead from outside due to sun-rays or other heat sources.

Now after I have listed the mechanical and electrical factors to be considered for the choice of materials to be used in the manufacture of signalling cables, naturally there exists a number of materials according to which so far, signalling cables have been built satisfactory, in the past.

The classical insulation materials for such cables have been impregnated paper and rubber compound. Sheating was done for paper-insulated cables essentially by a tight-fitting lead sheath, thus making the cable insensitive to moisture. The lead sheath being quite vulnerable mechanically and also sensitive to corrosion, had again to be covered by a heavy armour and other impregnating and serving materials, to attain desired stability and other mechanical properties.

Rubber compound insulations were less sensitive against moisture and could be covered, in addition to the armour, with a tough rubber sheath only in case of not being used underground. Rubber insulated cables for underground use had to be lead sheathed as well, for the purpose of preventing water absorption which would lead to a slow but continuous deterioration of the insulation properties even before the normal life of the cable.

The technological and mostly chemical progress during the last 25 years has created a vast number of new materials, mostly plastics, which have found entry also in the manufacture of cables for power and signalling, but predominantly in cables for telecommunication purposes using high frequency.

To elaborately mention here, plastics used mostly in high-frequency and telecommunication cables would go beyond the scope of this talk. I may mention here only the name of Styroflex or Polysterol as the basic compound made by polimerisation of Ethylene.

This plastic combines excellent electric properties surpassing even dry-paper insulated cables and is used mostly for carrier and other high frequency cables.

Although in electrical railway signalling, the conventional rubber or paper-insulated cables are still being used and have been found satisfactory, the new plastic materials, after having become competitive due to large scale manufacture, offer also many technical advantages. For signalling cables, these are insensitivity against moisture, high mechanical properties inclusive of resistance to ageing even under highly adverse circumstances, due to temperature and other influences, easy laying due to their low weight and especially easy connecting and

* D. W. Chilian is with Siemens Engineering & Manufacturing Company of India Ltd., Bombay.

jointing due to sealing of cable ends or pot-heads not being required.

This considerably simplifies the previously expensive laying and jointing process which on the other hand bears the danger with paper insulated cables that a complete cable might be lost if the jointing and pot-heating has not been done in an expert manner.

The new plastics have the advantage that, even should the plastic sheath become mechanically damaged, in most of the cases the inner insulation will not suffer even over extended periods, because the plastic insulation being mechanically much stronger than that of paper or rubber, and also being moisture proof.

Stressing now the verious properties of these new plastics as applied for signalling cables, it would take me too long to describe them item by item, and I have, therefore, shown in a table form (Table I), the most important mechanical and electrical properties in comparison to those of conventional rubber and paper insulations.

The table cannot be fully conclusive in all respects, and I may, therefore, mention in short, the inherent properties and advantages of the three main compounds :—

1. Polyvinylchloride = P. V. C.

This material has become well-known now in India under the trade name TROPODUR, and in view of Mr. Reddi's recent lecture, I would not again repeat too much. Let me only recall that PVC is used successfully for insulation and sheath, is moisture proof flame resistant, tough and its flexibility can be adjusted in the manufacture by the amount of plasticiser added in line with the temperature range for which it is required.

It is ideal for low voltage power and signalling cables, but not suitable for telecommunication circuits, because of its higher die-electric constant and also its rather low dissipation factor, which would cause too high attenuation in telecommunication circuits. The latter factors are, however, rather unimportant in conventional signalling circuits as is the case with rubber, which also could not be used in higher frequency telecommunication circuits.

Influences of high temperature with PVC may temporarily decrease its insulation value within permissible limits, similar as with rubber, however with the advantage over rubber, that insulation value will regenerate again with lower temperature and with no effect on the ageing properties, which is not the case with rubber.

2. Polyethylene = P. E. T.

Polyethylene has started in recent days to gain even preference over PVC at least as far as cable insulations are cencerned, for signalling and telecommunication cables. It's strikingly excellent electrical values make it suitable for higher frequencies where it is partly used in a 'foamed' form making use of small air-bubble enclosures in the compound to increase dielectric values and reduce dielectric losses.

For signalling cables, it is used in solid form for insulations, especially for cables, requiring small capacitance and very high insulation resistance, i. e. at the range of three to five thousand Megohm for 1000m of cable at 20°C.

It's only draw-back is, that PET is inflammable which in case of solidly sheathed and even armoured cables does not count too strongly because also oil-impregnated paper insulations are quite inflammable. Care would, therefore, only have to be taken at the loose connecting ends of the cables to avoid inflammation, the chances of which appear remote.

PET insulated cables are in most cases provided with a PVC sheath as outer protection, making it thus an ideal combination for a cable of outstanding electrical value with high mechanical properties, which can carry signalling and telecommunication circuits simultaneously.

3. Polychloroprene = PCP

PCP is a Polymerisation product of Chloroprene and its advantages are mostly its resistivity against ozone, light, oil and high temperatures. PCP can be considered as synthetic rubber and as such has high mechanical elongation properties required for flexible cable connections, even at very high temperatures. Its electrical properties are otherwise similar to those of PVC, with however, possibility of higher water absorption and also higher dielectric constant. PCP is mostly being used, therefore, for sheaths of flexible cable connections which are exposed to vibrations and also high temperatures and also chemical agents.

TABLE I

Table showing various properties for materials used for insulation and sheathing of signalling cables

Materials	Natural Rubber Compound Soft	Hard	Paper Dry	Oiled	P.V.C. (Tropodur)	P.E.T. (Polyethylene)	P.C.P. Synth Rubber (Neoprene)
1. Density (gm/cm^3)	1.0–1.6	Not	—	—	1.3 (1.35)*	0.93	1.3–1.5
2. Tensile Strength (Kgm/cm^2)	50–150	Used	—	—	125 (250)	100–190	75–100
3. Elongation (%)	250–300	For	—	—	125 (200)	100–600	400–600
4. Water Absorption (% 24 hrs.)	1–5	Cables	—	—	13 (0.5–1)	0.01	1–6
5. Dielectric Strength (Kv/mm)	15–30	20–30	10–20	40–50	20–35	60	20–30
6. Volume Resistivity at 20° C ($\Omega \times$ cm)	10^{12}–10^{15}	10^{14}–10^{16}	10^{15}	10^{15}	2×10^{10} (10^{12} – 10^{16})	10^{16}	10^{14}–10^{15}
7. Relative Dielectric Constant at 50 c/s = ε	3.5–5	3.2–4	2–2.5	3–4	3–8	2.3	3–20
8. Dissipation Factor tan δ at 50 c/s.	0.002–0.01	0.003–0.015	0.0025 0.004	0.003 0.01	0.012–0.15	0.002	0.02–0.4
9. Max. Temp. Range	+60°C	+60°C	—	45–65°C	+ 70°C	+100°C	+100°C
Application	Insulation & Sheath		Insulation	Insulation	Insulation & Sheath	Insulation	Insulation & Sheath

Note : *Values shown in brackets ( ) are applicable to TROPODUR.

The plastics now described, viz. PVC, PET and PCP are all of the thermo-plastic group, i.e. they are softening at high temperatures. This, however, does not constitute any drawback as they are blended in such a manner as to allow sufficient stability within the normal temperature range of application. Thermoplastic materials only are chosen for cable manufacture because of the manufacturing process requiring a continuous extrusion process for insulations and sheaths. Further limitations in application of other plastics lie merely in the question of suitable electrical properties and also their costs.

I am now coming to the second part of my talk which has a slightly varied subject.

As you all are aware, 50 c/s A.C. Electrification is in progress in Calcutta area, where A.C. traction of 25 kV has already been introduced on some sections.

Discussion of all the problems arising thereby in electrical signalling and telecommunication circuits would again lead too far within this talk and probably might be an interesting subject at some future occasion. Today, I would like to illuminate the situation arising with the view of adopting suitable signalling cables in this area.

The problem which arises is that of protecting signalling circuits from A.C. induction. In normal operation and with ordinary traction, currents in the range of 600 A are flowing in the overhead wires running parallel to signalling cables buried underground near the track, with a chance of traction short circuits when currents in a range of several Kilo-amperes are likely to flow, even if this would only be for a fraction of a second until the short-circuit breakers have reacted.

In the latter case such high voltage may be induced in the signalling cable that there is even a danger of flash-over between conductors and metallic sheath of cable.

In any case, the expected " interference " and the " critical voltage " must be found and brought up to an admissible value by protective means. In almost all cases, the required decrease in voltage is attained by the inductive protective effect of the cable sheath which is required to be from metal and which must be suitably adopted in order, to most effectively prevent interference. In the following, I shall examine the protective effect of various sheaths adopted for signalling cables with the view of the resulting reduction factors for various cable built-ups.

Before I, however, come to the reduction factor itself, I would like to show by a simple calculation in which way external electro-magnetic fields, as e.g. that of the overhead traction supply wire or catenary with return currents flowing through earth may induce interference voltages in a signalling cable running parallel to the tracks.

The interference voltage is induced lengthwise in the cable, i.e. potential difference Ei is between the ends of the cable and earth, as shown in Figure 1.

Normally that would have no detrimental effect provided the insulation of the cable against earth can withstand such voltage. In case, however, one conductor of the cable should be earthed incidentally or develop earth fault, the voltage Ei will distribute as shown in Figure 2.

Thus at the end, free from earth, a voltage of double the value, viz. 2×Ei will develop. In how far

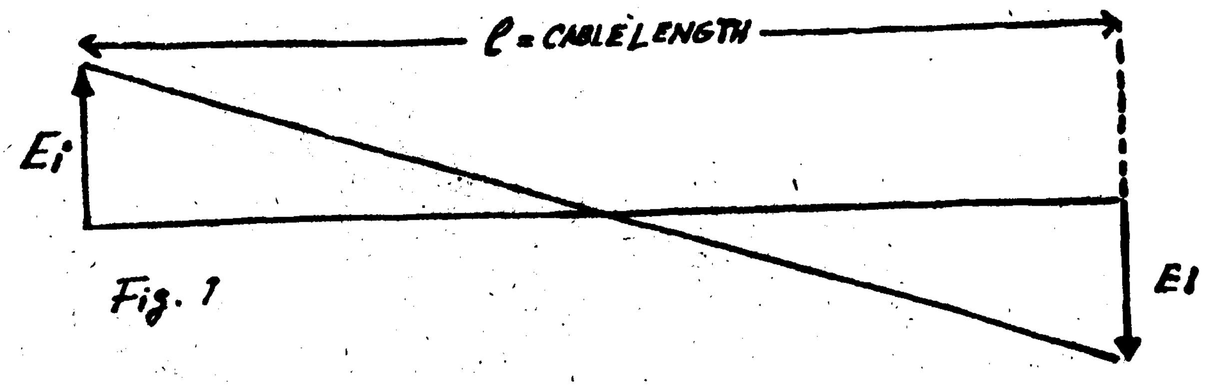


Fig. 1

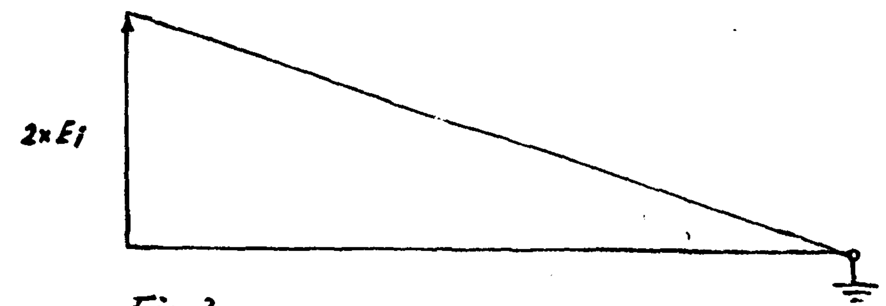


Fig. 2

*.12/

such voltage may already influence the working of the equipment, depends on the capacity of the conductors against earth which will now allow a capacitive current return to earth which may cause an A.C. Current to flow in a device connected at the cable end, as shown in Fig. 3.

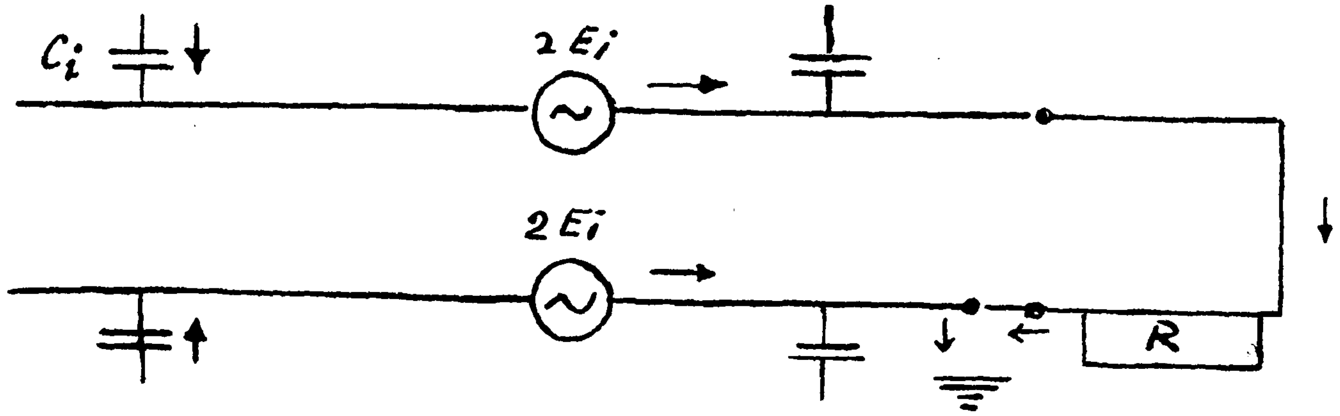


Fig. 3

This effect with a single earth fault as shown does already appear to cause a disturbance. Even with a limitation of signalling circuits to a length of approx: 3 Km and with normal traction currents and cable capacitance to earth, using however, unshielded cables, a current may flow of approx: 32.5 milli-amperes, due to Ei being about 295V and Ci = 170*nF*. as per formula

$$I = 2 \times Ei \times \omega C,$$

With ω being the angular frequency $2\pi \times f$ at 50 c/s, namely 314.

The above may become worse if at the place of Ci another full earth fault develops which would practically bring the full induced voltage of 2 x Ei to the terminals of the equipment connected to the cable.

For calculating Ei, the following values are of importance, which are roughly assessed as follows in A. C. electrified territory :

f — Frequency = 50 c/s.

M = Mutual inductance between contact wire and earth, and signalling cable and earth = 1.3 mH/Km.

l = Parallelism of signalling circuit in cables (length of control circuit) = max. 3 km.

J = Portion of the A. C. Traction current flowing through earth in KA (R. M. S.) = 0.6 KA.

r = Reduction Factor which takes into consideration, the effects of other earth-paths (such as rails) and cable sheathing = (0.4 for rails only).

By these values, the induced voltage Ei works out to :

$$Ei = 2 \times \pi \times f \times M \times l \times J \times r$$

which gives the already stated value of 295V when taking the basic factors, as stated, into account.

This formula shows clearly the importance of reduction factor, which in our calculation for Ei, has so far been neglected as far as the cable sheathing goes. Reduction factors, of screened signalling cables for instance, work out to between 0.3—0.5, which multiplied with the reduction factor due to rails gives a resulting factor of r = 0,16 if the same for cable is also 0.4.

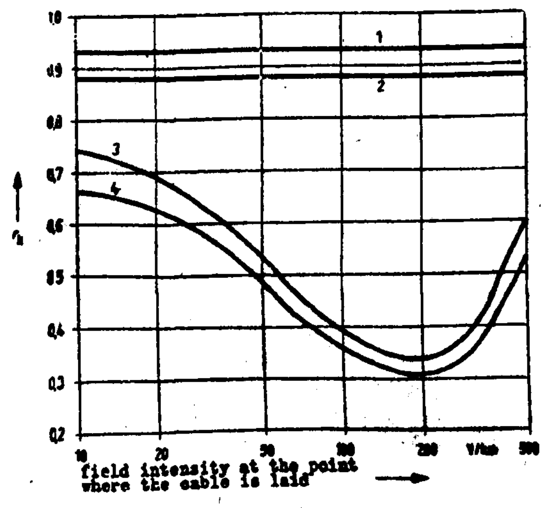
What is now influencing the reduction factor of a screened signalling cable? Actually the screening affect, i. e. reduction of induced voltage is expressed as reduction factor. It would lead too far here to go into a full mathematical calculation of the same, and I may just mention that the same may be expressed approximately by the following formula holding valid within the range of technical frequencies :

$$rk = \frac{Rg}{\sqrt{Rg^2 + \omega^2 (Li + La)^2}}$$

in which Rg represents the D. C. resistance of the cable covering, Li the internal self-inductance of the cable covering, La the external self-inductance of the cable with return circuit via earth and *w* the angular frequency.

The reduction factors which are obtained with the usual lead sheathed cables covered by various types of armouring are shown in table 2.

TABLE 2



These read as follows :

Curve 1 : For cable with diameter below lead of 10 mm, sheath thickness 1.1 mm, round wire armouring with wire diameter of 1.4 mm.

Curve 2 : For cable with diameter below lead of 20 mm, sheath thickness 1.1 mm flat wire armouring of 0.8 mm.

Curve 3 : For cable with diameter below lead of 30 mm, sheath thickness 1.2 mm, 2 layers of steel tape armouring, each 0.5 mm thick.

Curve 4 : For cable with diameter below sheath 40 mm, sheath thickness 1.3 mm, 2 layers of steel tape armouring each 0.5 mm thick.

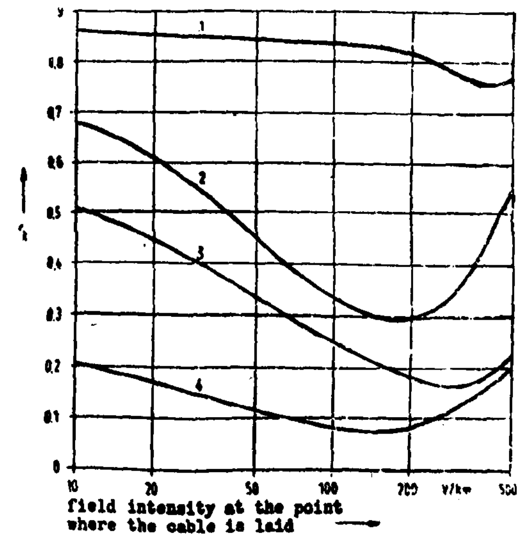
The above proves clearly that the reduction factor improves, i. e. gets lower, with smaller D. C. resistance of cable sheath which is either achieved by increasing thickness or overall cable diameter, or by increase of internal self-inductance of armour by using armouring material possessing higher permeability as for instance, special steel tapes.

The reduction factors to be analyzed next are those respecting sheet steel sheaths. Sheet steel sheaths have, as a rule, due to the thin sheet steel and inspite of the high specific conductivity, higher sheath resistances than lead sheaths. Consequently their protective effect is usually less than that of the usual tape armoured lead cables. The reduction factor, however, can be improved by a parallel connection of copper wires arranged below the sheet steel sheath. In cases where a greater protective affect is demanded, use is still made of the copper protection well-known for many decades, and formerly utilized more often with lead sheathed cables, but today for reasons of economy and the improved armouring material developed in the meantime is rarely used.

The protective effect of plastic sheathed cables is insignificantly small. For this reason, plastic sheathed cables are only utilized in those places where no special cable protective means are demanded or copper protection has to be used. The latter, due to the high metal prices prevailing today, is in the most cases, prohibitive. The disadvantages of plastic sheaths can usually be made up for by attaining higher insulation strength in case the emphasis is rather to avoid punctures of insulation in case of voltage surges by short circuits, which is, however, not so important with signalling cables which in any case are of high test voltage value compared to other communication cables.

I now come finally to reduction factors of aluminium sheathed cables which are rightly propagated today as the more or less final solution to overcome interference problems, due to A. C. induction. Due to their high conductance and protective qualities, aluminium sheathed cables are superior to all other types of cable design in both technical and economical respects where there is an interference problem. In table 3, a comparison is made between the various types of cable sheath designs with the protective effect of aluminium sheathed cables.

TABLE 3



A cable with a cable core diameter of 30 mm has been chosen as an example. The top curve applies to a " Protodur " sheathed cable with steel tape armouring and an additional flat wire armouring; the reduction factor of this cable does not even drop to 0.7. A more favourable factor is obtained by lead covered cable with steel tape armouring (curve 2). Curve 3 shows the reduction factor of a sheet steel sheathing cable, a copper protection of 8 sq. mm being applied to the cable core and two layers of steel tape armouring 0.8 mm being used to cover the sheet steel sheath. In this case, a very expensive process was chosen in order to decrease the reduction factor. The most favourable type of cable construction, however, is the cable with aluminium sheath (curve 4). With this cable, reduction factors below 0.1 are already obtained by using only normal designs for the cable covering.

The above proves clearly that for Railway Electrification territory, the most suitable cable sheath appears to be aluminium because of its high screening effects against induced voltages. Aluminium has further, quite a number of advantages over lead sheath, which are for instance, that the specific gravity of aluminium amounts to only approx : one quarter of the density of lead. When basing the comparison on average values, the tensile strength of aluminium will be approx : three times and its Brinell hardness approx : five times higher, the melting point, twice as high, the electrical conductance about eight times better than with lead. All these properties speak strongly in favour of aluminium as sheathing material whose higher hardness makes it possible even to dispense with additional armouring in case the aluminium sheath is chosen sufficiently thick to achieve the required reduction factor.

Generally, one could say that for signalling cables, a reduction factor of 0.3 to 0.5 appears to be quite sufficient, provided other safeguards are arranged for, in the circuits to protect against earth faults. Such safeguards are for instance, so called " double-cutting " of outdoor circuits and also a constant earth detection by a sort of proving relay bridge circuit. Even unarmoured, aluminium sheathed signalling cables with thickness of aluminium sheath being 1.5 mm provide such reduction factors and have the additional advantage that the reduction factor becomes independent of the field strength within the range of technical frequencies, unlike armoured, screened cables, where the minimum of reduction factor lies usually at about a field strength range of 200V/km and increases sharply at higher field strength.

The modern method in the manufacture of aluminium sheathed cables adopts nowadays also the extrusion process, so that the same can be manufactured quite similar as lead sheathed cables. Such cables combined with modern conductor insulations of PVC or PET as mentioned initially in my talk, provide today's best technical solution for effective screening combined with durability and excellent electric values not only for Railway Signalling Circuits, but also for many other applications in the field of telecommunication.

My talk today should have given you only a rough idea about the engineering and technical progress in the present development of modern cable manufacture. Naturally, it was not possible, therefore, to give extensive details. I should be glad, however, to answer any additional questions as far as my own knowledge goes or details are available with me.

The Use of Thermoplastics for Under-Ground Power & Control Cables

By C. A. REDDI, B. E. *

(Summary of the talk delivered in August 1960 before the Bombay Railway Signalling & Telecom. Society)

INTRODUCTION

PLASTIC insulated and sheathed house-wiring cables and industrial wiring cables have been used increasingly since the last war, when the development of plastics in the form of polyvinylchloride and polythene was accelerated with the shortage of rubber for cables. This trend was even more marked in America and Germany and in the latter country, shortage of lead during the war accelerated the development of plastics for power cables as well.

PRESENT POSITION

Overseas

On the European continent, p.v.c. insulated and sheathed unarmoured cables, with or without concentric copper neutral conductors beneath the sheath, are widely used for street lighting and service cables. P.V.C. armoured cables are used wherever mechanical stresses are encountered.

In America too, non-metallic sheathed cables having p.v.c., polythene or moisture-resistant rubber insulations for voltages upto 11 kV are being widely used.

The non-draining feature of thermoplastic cables has made them attractive for use in vertical situations in power stations in many countries, and they are increasingly used in the mines in Europe for this reason.

The development of plastic cables for service and distribution purposes in U.K. has been slower than on the Continent, and the British Standards Institution have recently issued a specification for p.v.c. armoured cables for voltages up to 3.3 kV.

Plastic cables are by no means being confined to voltages of the order of 660/1100 V, for in power stations in Germany, 20 kV p.v.c. cables are employed. A 30 kV p.v.c. Cable, manufactured by our Principals, SIEMENS SCHUCKERTWERKE A. G. Germany, has been in service since some time in the power station in W. Berlin.

At Home

The Indian Standards Institution had recognised the importance of p.v.c. as insulating material as long ago as in 1955 by issuing the specification IS 694 for p.v.c. insulated cables and flexible cords for electrical power and lighting up to 650 volts to earth (tentative). IS 694—1955 is at present under revision so as to include metric dimensions. The ISI have also recently brought out the specification IS 1554 (Part 1)—1961 for p.v.c. insulated (heavy duty) electric cables in rational metric sizes for working voltages up to and including 1100 V.

REVIEW OF DEVELOPMENTS

Up to the beginning of the 1930's, the conventional materials used for insulating and sheathing of cables were impregnated paper or rubber and lead respectively. Owing to the shortage of lead, an attempt was made by SIEMENS SCHUCKERTWERKE A.G. as early as in 1935 to substitute thermoplastics in the place of lead for sheathing paper insulated cores.

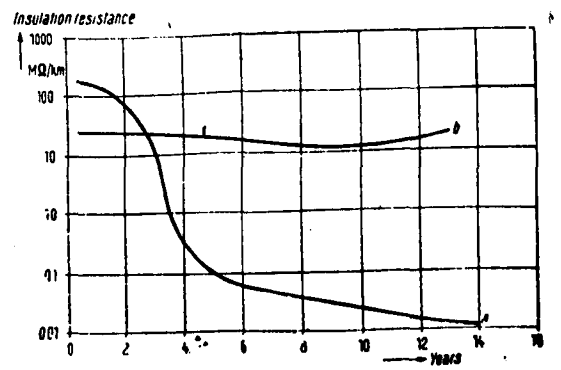


Fig. 1

a — 4×35 sq. mm. paper insulated, p.v.c. sheathed 1.1 kV cable

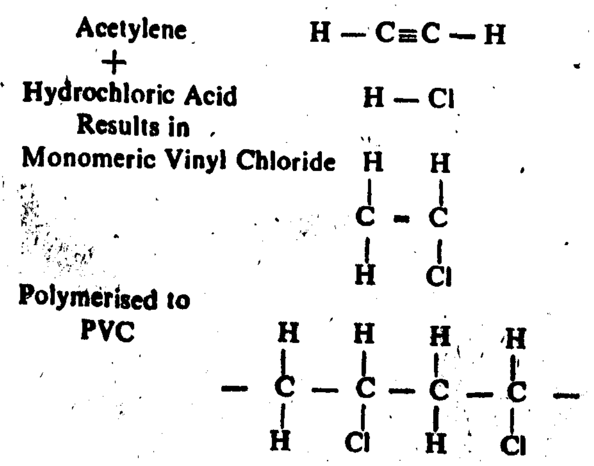
b — 3×25 sq. mm. p.v.c. insulated, p.v.c. sheathed 1.1 kV cable.

Fig. 1 — Variation of insulation resistance of cables buried in moist ground with respect to time.

* C.A. Reddi is with Siemens Engineering & Manufacturing Co. of India Ltd., Bombay

This type of cable was buried in moist ground and its insulation resistance measured over a long period of time. (Curve 'a' of figure 1). But the experiment proved to be a failure as the insulation value fell after a relatively short time. After about three years, the cable was no longer serviceable. It was found that traces of moisture which had seeped through the p.v.c. sheath into the hygroscopic paper insulation had greatly impaired the electrical values. And, this only confirmed that though all plastics do absorb moisture and allow it to seep through, the degree of absorption varies with different types. To overcome this defect, a special type of p.v.c. immune to moisture, was used for insulation as well as sheathing material. This type of p.v.c. insulated and sheathed cable too, was burried in moist ground and its insulation resistance measured over a long period (Curve 'b' of figure 1). The insulation resistance was found to be practically constant, even though it had a somewhat lower insulation resistance value than that of 'a'. These investigations therefore revealed that the small amount of moisture which might have penetrated through the p.v.c sheath is not detrimental to the p.v.c. insulation, since the electrical properties of the p.v.c. insulation are almost independent of the effects of moisture. Therefore, a cable with p.v.c. insulation, which is insensitive to moisture, does not require any water tight metal covering as in the case of paper or natural rubber insulated cables.

P.V.C. Compound



Structural formula of polyvinylchloride (p. v. c.)

The basic material for p. v. c. is obtained by preparing acetylene from calcium carbide and water. Further reaction with hydrochloric acid results in monomeric vinyl chloride, which after the addition of catalytic agent, can be polymerised to a highly-molecular produce, namely, polyvinylchloride (p. v. c.), This is brought about during the emulsifying process in which an emulsifier is used; the p. v. c. forms the solid constituent of a milky-whitish fluid and after vapourisation, the liquid is reduced to a white powder which is then ready for further processing. There is, however, the danger that residues of the emulsifier and electrolyte may remain in the polymeride emulsion.

P. V. C. almost pure and free from electrolyte, is obtained by the suspension process. In other words, the monomeric vinyl chloride and the catalytic agent are simultaneously suspended finely and polymerised. A very pure p. v. c. powder practically free from electrolyte is obtained after washing the filtered material. This is done in order to remove the catalytic agent.

P. V. C. in its pure form is hard and brittle at normal ambient temperatures. Plasticisers i. e. oily liquids of ester structure and stabilisers are added in order to give it the required leather-like toughness and chemical stability at high temperatures. Fillers improve resistance to corona discharge and improve the flexibility at low temperatures. Pigments are added to give the compound bright and easily distinguishable colours. The overall p. v. c. sheathing of L. T. cables, however, is only in black, because of its superior weathering characteristics.

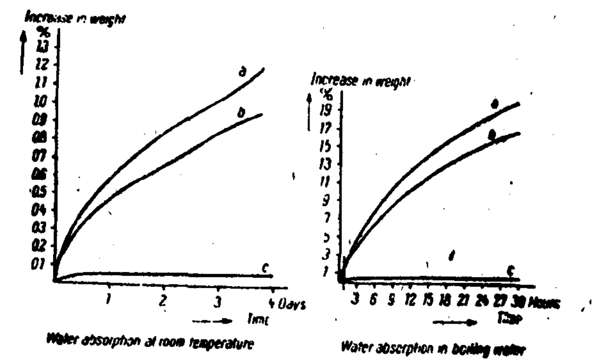


Fig. 2

Fig. 2—Water absorption of p. v. c. compounds.

Curve 'a' of figure 2 shows the water absorption of p. v. c. compound obtained by the emulsion process, while curve 'b' refers to the ordinary p. v. c. compound obtained by the suspension process. The curve 'c' refers to the compound used by SIEMENS SCHUCKERTWERKE A. G. This compound is specially blended from p. v. c. powder obtained by the suspension process, which is practically immune to moisture.

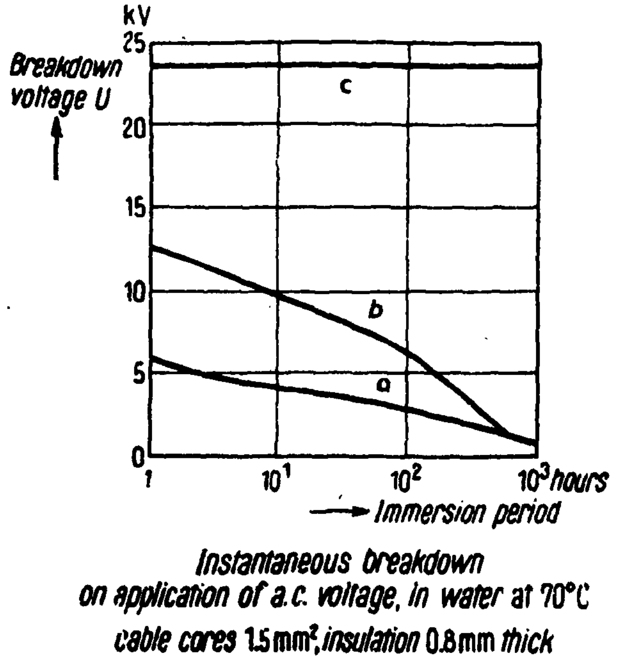


Fig. 2-a

Fig. 2a— Electrical characteristics of p. v. c. compounds.

The instantaneous breakdown voltages as a function of the time in water at 70°C for this compound are plotted as shown in figure 2a. It can be seen that curve 'c' with the lowest water absorption has the highest initial value for the breakdown voltage, which is practically independent of the duration for which the componud is in water. The instantaneous break-down voltage of compounds 'a' and 'b' with a higher water absorption rate, shows a rapid reduction. After about 1000 hours in water, the dielectric strength falls almost to zero and they are therefore no longer fit for use as insulating material of cables. From this and many other investigations it has been concluded that only a compound with a low water absorption and with characteristics similar to those of compound 'c' are suitable for use as cable insulation.

As a result of many years of intensive research, SIEMENS SCHUCKERTWERKE A. G. have developed suitable grades of p. v. c. compound, using suspension processed powder, similar to curve 'c' for insulation and sheathing of cables. This non-hygroscopic compound carries the registered trade name PROTODUR in Germany and TROPODUR in India. TROPODUR is used as insulating and sheathing material by CABLE CORPORATION OF INDIA LIMITED, an Indo-German venture, in the manufacture of p. v. c. wires and p. v. c. power and control cables up to 1.1 kV, under licence from SIEMENS SCHUCKERTWERKE A. G. Since PROTODUR and TROPODUR are identical, their important properties are summarised in the following table :

Specific density	1.35 g/cm³
Tensile strength	150 to 250 Kg/cm²
Elongation	150 to 250%
Water absorption in boiling water	0.5 to 1% in 24 Hrs.
Specific resistivity at 60°C	10^{12} to 10^{15} Ohm-cm
Puncture voltage	20 to 35 kV/mm
Dielectric constant	5 to 8
Operating temperature range	—40°C to +70°C

MANUFACTURING PROCESS

Only through careful and proper processing will good materials yield good results. Therefore the factory of CABLE CORPORATION OF INDIA at Borivli, one of the most modern cable factories now existing in India, is equipped with the latest machinery with automatic and semi-automatic controls for temperature regulation and quality control during the insulation and sheathing processes. A brief description of the manufacturing process is given below.

Fig. 3

Fig. 3— An extruder press with a control panel for controlling the temperature in the three zones of extruder press

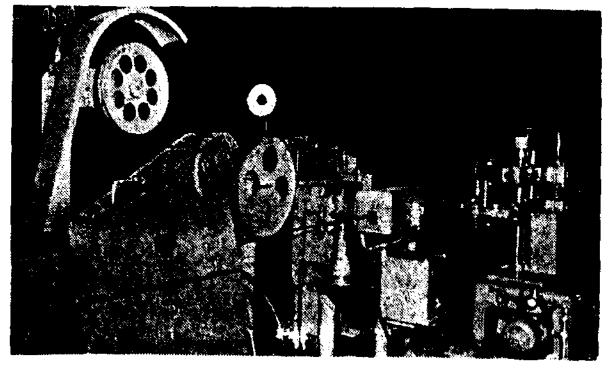


Fig. 4

Fig. 4— A diameter controller and spark test equipment.

P. V. C. granules are fed into the hopper of the screw-thread extruder-worm (Fig. 3). The extruder-worm is heated stepwise ; and p. v. c. granules pass through different heat zones before reaching the nipple. The gelatinised p. v. c. comes out of the nipple to form a coating of predetermined thickness over the warmed plain copper conductor passing through the nipple. The coated conductor i. e. the core, passes through the diameter controller (Fig. 4), which checks the core diameter and is then continuously spark tested at 8 kV a. c. (Fig. 4) before being wound at the winding stand.

QUALITY CONTROL

High quality in production can only be achieved through careful and proper selection and processing of raw materials. In addition to automatic and semi-automatic controls of the machinery the factory has established manual (production and quality) control departments which independently check the quality of the product at each stage of its manufacture. The former employs supervisory staff specially trained for this type of work while the latter is manned by highly qualified engineers. Each of the above departments sees that the product at every phase of its manufacture conforms strictly to the relevant specifications.

TESTING LABORATORY

The vital centre for certifying the specified quality of the raw materials used, and of the semi-finished and finished products, is the factory's well equipped testing laboratory. Its zone of testing is spread over the entire factory starting right from the raw materials down to every length of the finished product that leaves the factory. The test laboratory, therefore wields the onerous responsibility of ensuring that the finished product is of uniform quality.

Every cable drum rolling out of the factory is tested at 4 kV A.C. or 12 kV D. C. The cables are also subjected to a number of extremely rigorous tests to ensure the high quality and dependability which characterise these p.v.c. cables.

CHARACTERISTICS OF P.V.C.

P.V.C. is a thermoplastic ; at low temperatures it becomes harder and at high temperatures its mechanical strength decreases. This fundamental property of p.v.c. is however no hindrance in practical operation. Even at high temperatures, such as those which occur under short-circuit conditions, correctly mixed and processed p.v.c. compound have good mechanical stability. Under the effect of mechanical short-circuit stresses, even the most highly stressed insulation retains its shape. Short-time conductor temperatures of 200°C and continuous temperatures of 70°C are permissible. In addition to this, the compounds do not change chemically.

The current ratings of p.v.c. cables are based on a maximum conductor temperature of 70°C instead of 80°C as for paper cables. In consequence, their ratings are slightly lower than those of paper cables by 5% to 10%.

As is the case with all cables, overloads of longer duration, frequent exposure to heat, for instance, due to hot pipes, radiation from molten substances or industrial furnaces, etc. reduce the life. Despite this, it has been found that the life of p.v.c. cables tends to be longer than that of paper-insulated or rubber-insulated cables.

P.V.C. is resistant to most of the chemicals used in chemical and petroleum industries including those present in the soil. Even the best of p.v.c. mixtures could be affected by a few chemicals especially of the aromatic hydro-carbon origin. However, an occasional contact with such chemicals does not damage p.v.c. In case these p.v.c. cables have to be used in locations where prolonged effect of such aggressive organic compounds is to be expected or in installations where these compounds can spill over the cable, preference should be given to p.v.c. insulated lead-sheathed cables.

Micro-organisms such as are found in soil do not destroy p.v.c. There is likewise no danger from fungi to which organic substances are exposed in tropical countries.

P.V.C. is flame retardant; it does not support combustion and is self-extinguishing when the source of ignition is removed.

ADVANTAGES OF PVC CABLES OVER PAPER CABLES

Smooth and clean surface.

Very high resistance to ageing.

Insulation unaffected by moisture.

Reduced weight and therefore easier to install.

When a large number of cables have to be installed together, the supporting structures can be made appreciably lighter than in the case of paper-insulated lead-sheathed cables. Smaller bending radius (i.e. twelve times the cable overall diameter) permit better space utilisation.

No compound drainage troubles and particularly suitable, for vertical insulation, since the cables do not contain impregnating compound. Thus no special measures are necessary, as is the case with paper insulated cables. Differences in the level of the run thus present no difficulty and it is simple to connect down-coming cables and in some cases for suspension connection.

Resistance to chemicals.

Flame retardant.

P.V.C. cables are ozone-resistant, a fact which is of great importance especially when laid in open air. In the vicinity of high frequency installations or sources of ultra-violet rays, ozone may be produced which, if highly concentrated, destroys rubber within a short time. P.V.C. cables however are completely unaffected by ozone.

P.V.C. cable is corrosion-resistant and is also resistant to D.C. voltage effects. Wherever D.C. stray currents represent serious danger to cables, e.g. in electrolysis plants, battery rooms, D.C. tramways, etc. p.v.c. cables can be used without any restriction.

P.V.C. cables are also resistant to temperature. In other words, p.v.c. cables can withstand a temperature of 70°C at the conductor. The high softening point offers the advantage that the cable clamps make no dents in the sheath of the cable even when the cable is carrying the full rated current continuously. The high short circuit strength is also a result of this high softening point. It is also possible to use PVC cables at temperatures higher than that specified i.e. about 70°C, however, in which case its life would be considerably reduced.

Similar jointing, requiring no plumbing, P.V.C. cables do not require any indoor cable end box as they can be directly connected to distribution boards and motor terminal boxes, thus saving a lot of space, material and installation time. The installation can be done even by semi-skilled personnel.

APPLICATION

P.V.C. insulated and sheathed unarmoured power and control cables can be employed in all types of heavy duty medium voltage systems indoors and outdoors, in ducts and in air. P.V.C. insulated, round steel wire or flat steel tape armoured, p.v.c. sheathed cables are being increasingly employed under a variety of installation conditions including direct burial in ground, in power stations, industrial premises, electricity distribution, street lighting, railway signalling and as service cables.

On account of their high resistance to the effects of chemicals, thermoplastic cables are used in the chemical industry, in electro-plating and 'pickling plants, in battery rooms, in coal washing plants, etc.

Fig. 5

Fig. 5 — *Types of TROPODUR cables* (from top to bottom)

3×10 rm YY, Eo/E=0.66/1.1 kV (Power Cable)

4×2.5 re YRY, Eo/E=0.66/1.1 kV (Power Cable)

19×2.5 re YFY, Eo/E=0.66/1.1 kV (Control Cable)

ACCESSORIES

The wide range of application of p.v.c. cables in the Continent necessitated the development of special accessories to suit the varied operating conditions encountered. With the application of cold setting casting resins, SIEMENS SCHUCKERTWERKE A.G. covered new ground in this field and, are marketing this type of compound under the trade name 'PROTOLIN'.

PROTOLIN is a cold setting casting resin mixture, which with the addition of a hardner polymerises at ambient temperatures within 4/8 hours. PROTOLIN is to a great extent, insensitive to chemical and atmospheric effects. Its electrical and mechanical properties are outstanding and meet most of the requirements specified in cable engineering.

PROTOLIN is stable during short circuit conditions, space saving, light in weight and resistant to ageing even where most difficult conditions are encountered. Among the outstanding properties of PROTOLIN is its optimum electrical quality even under the permanent effect of dampness, and direct current.

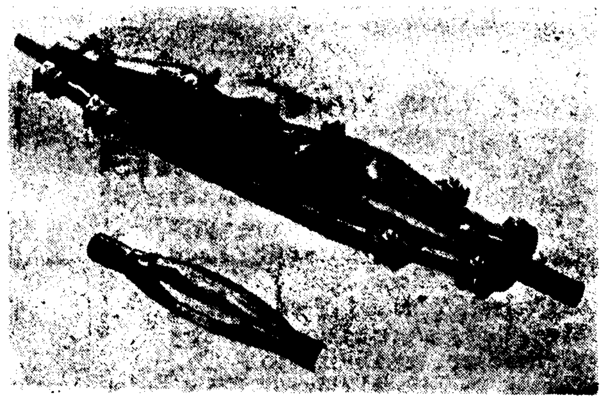


Fig. 6

Fig. 6 — Comparison of cast iron joint box and cast resin sleeve for the same p.v.c. cable cross section.

PROTOLIN can be used for jointing and terminating p.v.c. cables. And the usual type of compound filled cast-iron joint and end-boxes employed with paper insulated cables may also be used. The bituminous compound should be heated first to its maximum allowable pouring temperature and then allowed to cool down to 120°C before actually pouring it into the boxes.

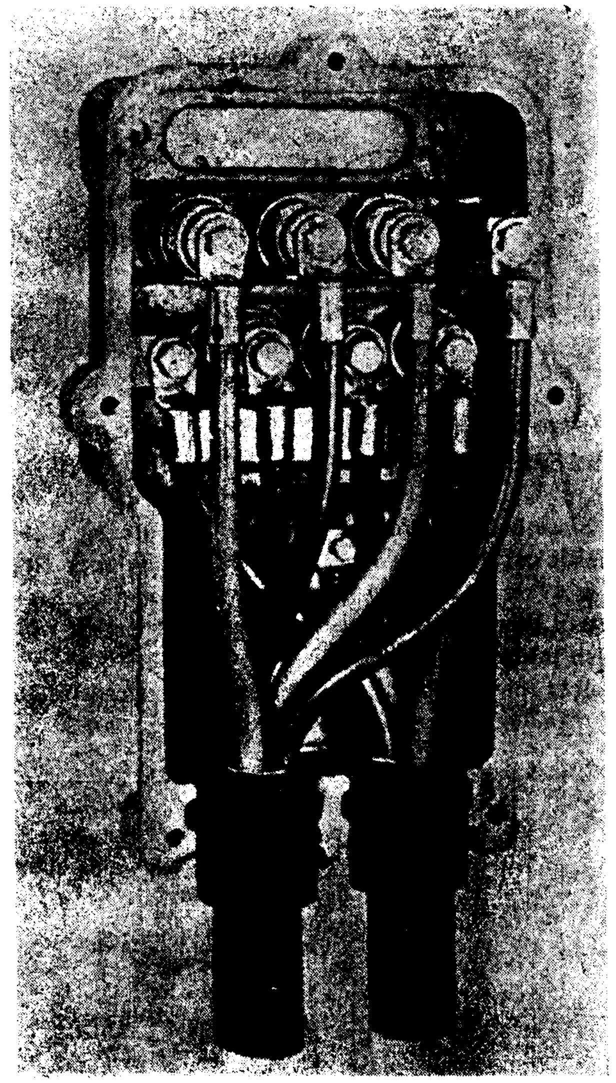


Fig. 7

VARIOUS METHODS OF INSTALLATION

Fig. 7 — Direct connection of TROPODUR power cables in motor terminal box

Fig. 8

Fig. 8 — TROPODUR power cables connected directly to indoor busbars under cramped conditions and with vertical top entries

Fig. 9

Fig. 9 — TROPODUR power and control cables in a control board panel

PROSPECT

Since many of the problems of introducing thermoplastic cables in this country have already been solved, it is a fair assumption that the rate of increase in the use of thermoplastics for underground cables will be such that the low voltage paper and rubber cables may well be replaced by p.v.c. cables within a decade in India.

(Photographs by courtesy of M/s. CABLE CORPORATION OF INDIA LIMITED and SIEMENS SCHUCKERTWERKE A.G., GERMANY).

Acknowledgement is made to M/s. Siemens Engineering & Manufacturing Co. of India Ltd., for permission to publish this article.

IN YOUR OWN INTERESTS

HOW TO PURCHASE TICKETS

Buy your tickets only at the proper place. The authorised offices are (i) the Booking offices at the railway stations, (ii) the Town or City Booking Offices, (iii) the Out-agencies, (iv) Travel Agents. Never buy tickets from any other source as that may lead you to trouble. Please note that tickets are not transferable.

Buy your tickets in the proper time. You can avoid unnecessary excitement and trouble if you come to the station in good time, that is at least half an hour before the scheduled departure of your train. The Time Tables of the Railway are on sale at Booking Offices and Bookstalls.

Buy your tickets in the proper manner. Queue up at the Booking Window and you can get your ticket easier and quicker than by crowding at the counter.

By handing in the *exact fare in good coins or currency* you get the ticket easier and quicker, and save for yourself and the Booking Clerk time and trouble.

Check up your ticket and money before leaving the counter and draw the attention of the Booking Clerk to any discrepancy you may notice.

(Inserted in the interests of Travelling Public)

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CLEANLINESS LEADS TO HEALTH AND HAPPINESS

Clean orderly habits contribute to general health and welfare and as such to happiness and prosperity; they are more important than medicines.

Cleanliness prevents disease; medicine only attempts to cure.

Cleanliness of the person, of the houses and colonies, reflects discipline in the individual and the community. Discipline is the foundation stone for progress of oneself and the country. Cleanliness is a good habit. It is also cheap.

All Railwaymen should set an example of cleanliness. This will help others and themselves.

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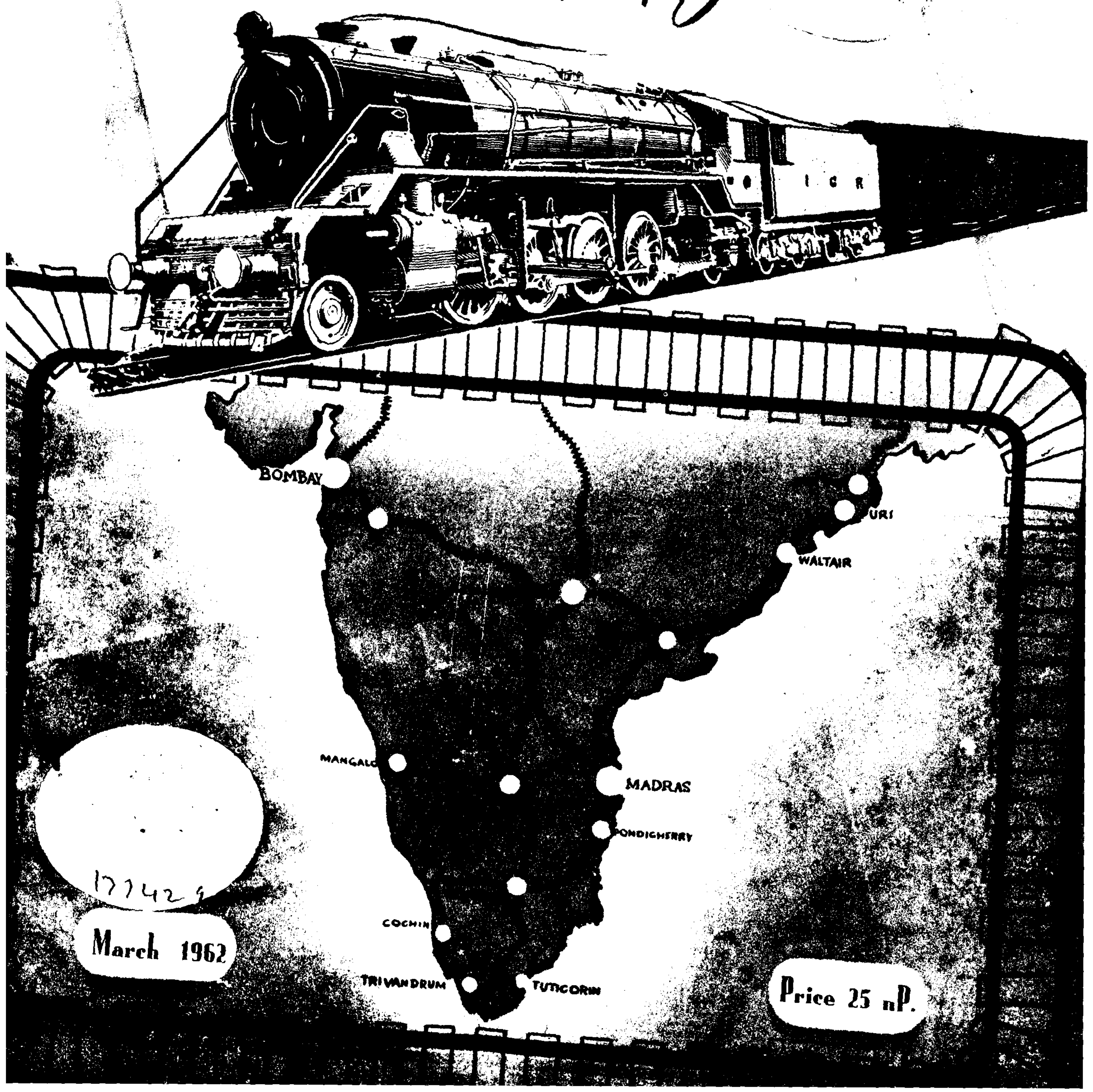
Edited by: T. S. Krishna Rao

SOUTHERN RAILWAYS *Magazine*



GOLDEN RULES OF CONDUCT FOR RAILWAYMEN

1. Do you plan your work daily? Get the more essential things done first and do not neglect the important ones sidetracting them to the fag end of the day.

2. Do not express casually careless opinion. Never venture forth an opinion unless asked for it.

3. Remember that most of our mental worries come either from trying to fight life hard or from trying to run away from life. Do neither.

4. Learn to accept people as they are, love them, respect them, praise them, encourage them, differ with them, but above all, learn the priceless art of give and take.

5. Cry neither for the moon, nor over spilt milk.

6. Accept the things that you cannot change; have the courage to change the things that you can, and possess the wisdom to know the difference.

7. Do not drive too hard a bargain with yourself.

8. Accept life as it is—its wonders, changes, disappointments, frustrations etc., etc.

401 Series Silicon Rectifier System A.C.-D.C. Electric Multiple Unit Coaches

The 401 series A.C.-D.C. electric multiple unit coaches are the self-propelled electric coaches designed for service on a line which includes the sections of both A.C. and D.C. system. Using latest technical developments including silicon rectifiers and A.C.-D.C. changeover circuits which are activated aboard the train, the coaches of this series are the first A.C.-D.C. dual system electric coaches to be manufactured in Japan.

INTRODUCTION

AS a result of several years of research work, the future standard for the electrification system of Japanese National Railways has recently been set for A.C. 20 kV of commercial frequencies of 50 cycles and 60 cycles, instead of D. C. 1,500 V as hitherto. Already, some parts of the Senzan Line, Hokuriku Line, Tohoku Line, Joban Line and Kagoshima Line have been electrified under the A.C. system.

In all these lines, newly electrified A.C. sections have to be connected with the already established D.C. sections. Electric coaches serving on these lines which have dual electrical systems must be capable of operating in both sections of the electric systems. The 401 series A.C.—D.C., E.M.U. coaches were designed for this purpose, and are to be commissioned first on the Joban Line. A prototype train was manufactured in June 1960, and mass produced coaches of this type started coming off the production line in the spring of this year.

Hitachi, Ltd. is well experienced in the manufacture of not only D.C. electric cars but also A.C. cars. In the manufacture of the 401 series coaches, the company took maximum advantage of the experience which

Fig. 1. Outside View of 401 Series A.C.-D.C. E.M.U. Coaches

had been accrued in producing the ED 46 type A.C.—D.C. electric locomotive.

GENERAL CONSIDERATIONS

These electric cars are designed to run through sections of two differing electrical systems on the Joban Line. The Line, partly electrified in A.C. 50 cycle 20 kV, has an earlier electrified section of 1,500 V D.C.

The features of the 401 series coaches are listed below :

1. These coaches are always operated in a train of 4 coaches as one operating unit, and as

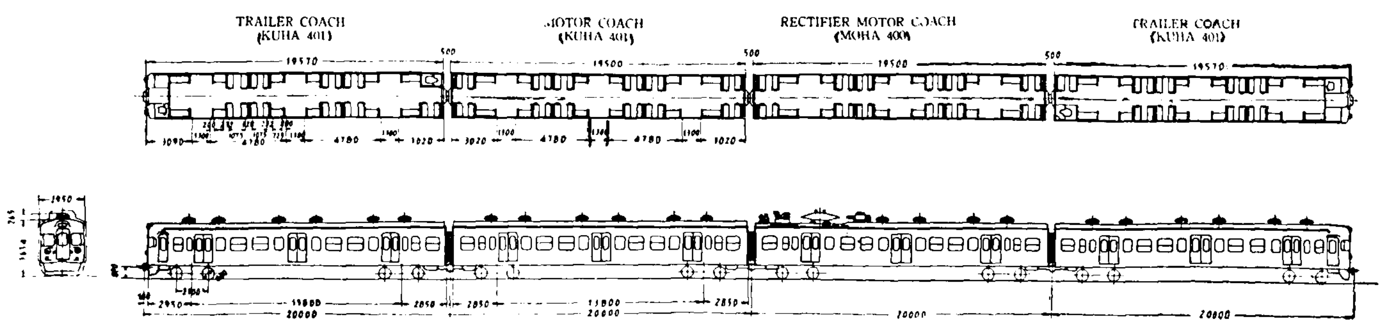


Fig. 2. 401 Series Electric Multiple Unit Coaches

the occasion may demand, can be operated in long trains consisting of 2 to 3 units. Of the four coaches forming one operational unit, those at each end are trailer coaches. One of the motor coaches is the power supply coach in which is located all the necessary A.C. high tension equipment.

2. In the A. C. section, the A. C. overhead current is rectified into D.C. 1,500 V to drive the main motor. The rectifier used is the silicon rectifier.
3. While the train is running, the driver can effect a changeover from A.C. to D.C. operation or vice versa.
4. All the high voltage equipment for the A.C. circuit is located on the roof of the coach, while the main transformer, silicon rectifiers and other equipment are installed under the floor.

The main specifications of these electric multiple unit coaches are given in *Table I*. *Fig. 2* shows their external appearance.

CAR BODY

The car body frame and underframe are of light weight monocoque structure which is an assembly of light gauge steel and pressed steel plates welded together. The side panel is of 1.6 mm thick cold

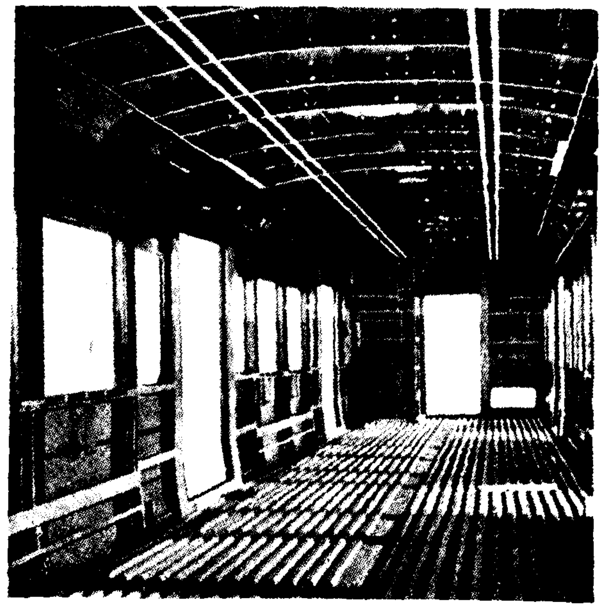


Fig. 3. Interior View of Car Body Structure

TABLE I.

Comparison of Space Factor for Each Type of Core Based on Internal Area of Coil.

1. Passenger capacity and empty weight :	
2nd class control coach (KUHA 401)	116 passengers 30 tons
2nd class motor coach (MOHA 401)	128 passengers 37 tons
2nd class motor coach (MOHA 400)	128 passengers 42 tons
2. Performance of 1 unit of motor coach :	
1 hour rated output	775 kW
1 hour rated tractive effort	
70% field	59.6 km/h
40% field	78.6 km/h
3. Maximum operation speed	95 km/h
4. Drive wheel diameter	860 mm
5. Gear ratio	17 : 82 1 : 4.82
6. Traction motor	MT 46 B, 375 V, 100 kW, 300 A, 1,860 rpm
7. Main transformer	For suspension under the floor ; radial core type; continuous rating of 807 kVA.
8. Rectifying system	Forced ventilation type silicon rectifier
9. A.C.—D.C. changeover	Simultaneously power off and power on : in sequence
10. Control system	Series-parallel, field weakening, multiple unit control rheostatic brake
11. Braking system	
Motor coach	Combined automatic and electromagnetic straight brake with rheostatic brake
Control coach	Combined automatic and electromagnetic straight brake, and hand brake

rolled steel sheets while 1.2 mm thick cold rolled steel sheet is used for roofing. The side post, carline and cross beams are arranged on the same cross section in a circular layout. The center sill of the underframe is installed outside the bolsters only and not between the bolsters. Instead, a corrugated keystone plate covers the entire area of the upper surface of the underframe in a longitudinal direction. Shocks inflicted on the ends of the coach are to be borne by this keystone plate and the side frame.

The passenger room has a ceiling of 1.6 mm thick aluminum alloy sheet coated with white melamine plastic paint. The inside of the room is paneled with melamine plastic coated board of light green color. Melamine plastic board requires little maintenance care because it needs no painting, stains are easily removed, and it is difficult to damage. The floor consists of a 15 mm thick veneer board covered with vinyl chloride sheet.

Special consideration was given to the arrangement of the passenger rooms of these A.C.-D.C. E.M.U. coaches because these coaches in view of their service area, serve not only as commuter trains but also as inter-urban trains. To elaborate, 3 entrances each measuring 1,300 mm in width are installed on each side. Seats are arranged in the longitudinal direction while there are cross seats between them and towards the car ends.

A total of six chimney type ventilators are installed in the roof of each coach. Fans are installed on the ceiling of the passenger room. High voltage equipment prevents the installation of ventilators on the low roof part of the power supply coach and due to the low ceiling, it is also impossible to install fans on the ceiling. Instead, "chandeliers" are installed there.

The space between the roofing plate and ceiling board at this part serves as a wind duct which takes in fresh air from inlets opening on both sides of the roof. For heating during the winter season, an electric heater is installed under each seat.

The window frame is made of extruded aluminium. The window, divided into upper and lower parts, is opened by lifting each of the parts upward. The window is fully opened when both parts have been lifted. Each side entrance consists of two sliding doors opening in opposite directions. The sliding doors are simultaneously opened and closed by a single door engine which is installed above the door. All doors of a train are opened and closed simultaneously by the conductor in the conductor's cabin.

A novel device in this coach is the disposer installed in the lavatory. In this disposer, a disc is revolved at high speed by motor to pulverize human excreta. It is then reduced to a harmless and odorless fluid by the addition of a chemical liquid for release outside the coach.

TRUCK

The DT 21 B type truck is used in the motor coach and TR 64 type truck in the trailer coach. The DT 21 B type truck is roughly identical with the TR 64 type truck except that it has a main motor.

The three point support system involving a center plate and side bearer is utilized. The center plate bears 80% of the entire load and the side bearers 20% and a swing bolster is also used. For a smooth sliding effect, the side bearers are treated with molybdenum disulphide.

The truck frame is of H shape, without an end beam. It is made of 9 mm thick ordinary steel plate pressed into one body and assembled by welding.

Measuring 860 mm in diameter, the wheel is made of solid rolled steel. Double roller bearings are used.

Coil springs are used for the bearing springs and bolster springs. Vibration absorbing rubber is used with the bearing springs and the oil damper with the bolster spring for greater riding comfort.

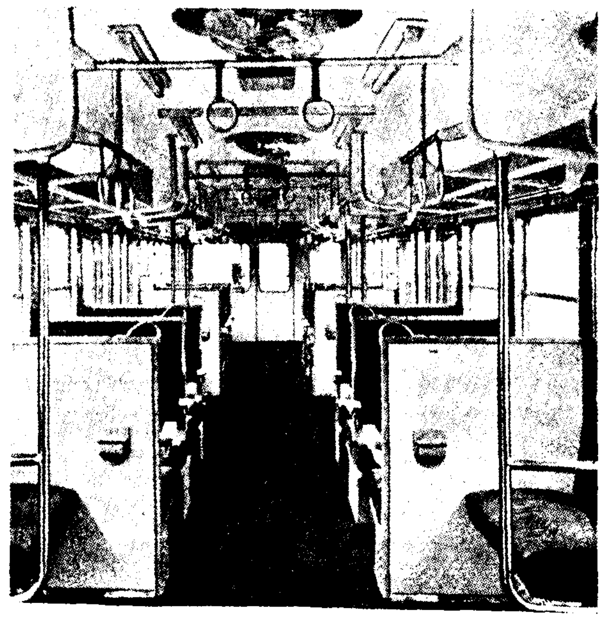
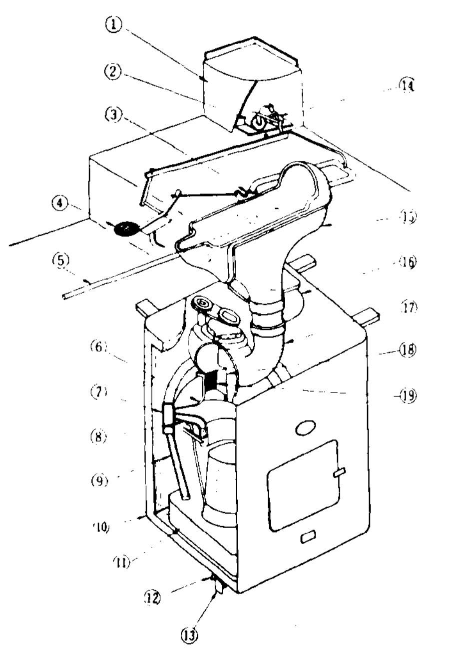


Fig. 4. Interior of Coach



1. Processing Liquid Tank
2. Time Switch
3. Flush Valve
4. Pedal
5. Fleaning water
6. Upper Body
7. Drain Duct
8. Disc
9. Pipe
10. Cold Shielding Material
11. Tank
12. Basket
13. Drain Pipe
14. Processing Liquid Valve
15. Stool
16. Drive
17. Introducing Duct
18. Moving Blade
19. Pulverizing Section

Fig. 5. *Disposer*

The braking system employs brake shoes throughout. Those used on the TR 64 type truck are of cast iron, while those used on the DT 21 B type truck are of a resinous material which functions well with rheostatic brakes.

BRAKING SYSTEM

The braking system uses SED type which combines the automatic and electromagnetic straight brake with the rheostatic brake. The main part of this brake is the electromagnetic straight brake. The rheostatic brake is used together with this brake in the motor coach. The automatic brake works when there is trouble in the electrical circuit of the electromagnetic straight brake, when the conductor's valve is operated or when the coupling between coaches is disconnected.

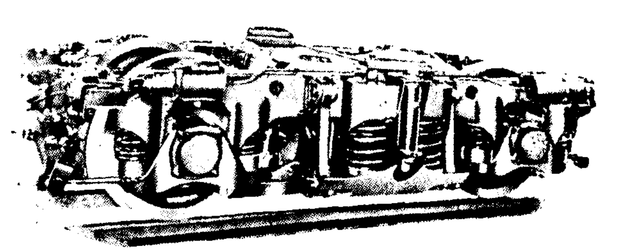


Fig. 6. Motor Truck

Mutual changeover between the rheostatic brake, the electromagnetic straight brake, and the automatic brake actions are all brought about by a single brake valve handle. The electromagnetic straight brake of this unit has a self-lapping mechanism. The braking force is maintained automatically at a constant value according to the angle of the brake valve handle. Hand brakes are installed at both ends of only the KUHA 401 to be operated from the conductor's cabin.

ARRANGEMENT OF ELECTRICAL EQUIPMENT

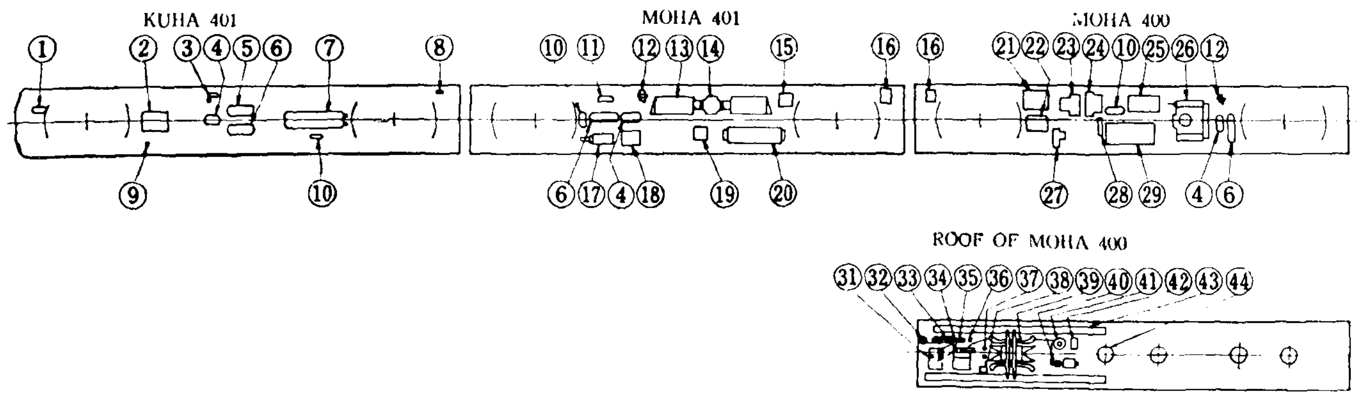
All the equipment for the alternating high voltage current is installed on the roof of the MOHA 400 coach. Other alternating current equipment such as the transformer and silicon rectifier is suspended under the floor of the MOHA 400 coach. D.C. equipments such as the main controller, main resistor and motor generator are concentrated in MOHA 401 coach.

In consideration of the limit gauge, that part of the roof of the MOHA 400 coach where equipment is installed is lower than the other part of the roof. The A.C. high voltage current is conducted from the cable head to the transformer under the floor by a special high voltage cable. The portion of this cable which descends below the floor must be protected from damage in case of an accident. For this purpose, the cable is routed through the end post which is formed in a sturdy box shape.

Fig. 7 shows the arrangement of the main equipment and *Fig. 8* the installation of the equipment on the roof of MOHA 400 coach.

ELECTRICAL SYSTEM

A schematic diagram of the power circuit is given in *Fig. 9*. These E.M.U. coaches contain the silicon rectifier system and can be operated by either A.C. or D.C. When the train is operating in the A.C. 1-phase 50-cycle, 20 kV section, the voltage is stepped down by the main transformer, rectified in full wave by the silicon rectifier and is then used to drive the series wound D.C. traction motors and the auxiliary motors. In the D.C. section, D.C. 1,500 V is taken directly from the trolley wire to drive the traction motors and others.



1. Equalizing Reservoir
2. Air Compressor
3. C-2 Brake Control Device
4. Auxiliary and Supplementary Reservoir
5. Main Reservoir
6. Suppling Reservoir
7. Water Tank
8. Disposer
9. Multiplier
10. Control Air Reservoir
11. Voltage Stabilizing Device Box
12. C-1A Brake Control Device
13. Main Resister
14. Motor Fan
15. Inductive Shunt
16. Connection Box for Main Circuit
17. Motor Generator
18. Starting Equipment for M-G
19. CB-13A Circuit Breaker Box
20. CS-12B Main Control Box
21. A.C./D.C. Change Over Switch
22. Main Reactor
23. CB 12A Circuit Breaker Box
24. A.C. Filter
25. Battery Box
26. Main Transformer
27. Aux. Circuit Breaker for D.C. Auxiliaries
28. Current Minimizing Resistor
29. Silicon Retifier
31. A.C. / D.C. Disconnecting Switch
32. Cable Head
33. Main Fuse
34. Air Blast Circuit Breaker
35. D.C. Arrester
36. C.T.
37. Air Duct Insulator
38. Eathring Switch
39. Pantograph
40. P.T.
41. A.C. Arrester
42. Resistor Box for D.C. Voltage Relay
44. Ventilater

Fig. 7. *Arrangement of Equipment*

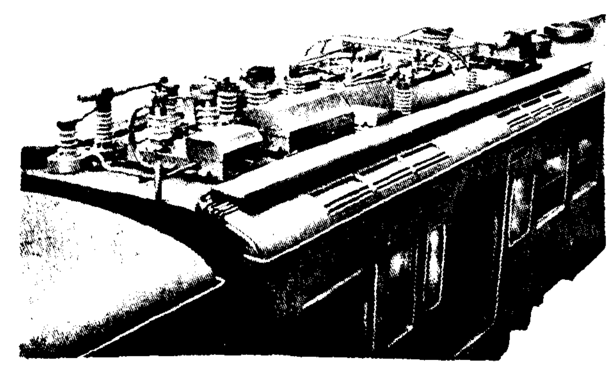


Fig. 8. Equipment on the roof (MDA 400)

The changeover control system can be operated from the operator's cabin while the train is running. As for the changeover from A.C. to D.C. or vice versa, the main circuits of all coaches are switched off simultaneously before the train enters another current section, and upon entering the different current section, the main circuits are switched on automatically from the first unit to the last one in order. To detect A.C. or D.C., each rectifier-motor coach has a potential transformer, a D.C. voltage relay and an A.C. voltage relay so that in the different current section an air blast braker is interlocked and cannot be switched on, even when the operator has misoperated.

To insure safety even in the event that the train enters a different current system without switching over, there are complete safety devices composed of a main fuse in the D.C. section, and a D.C. lightning arrester and an A.C. overcurrent relay in the A.C. section.

The speed of the train is controlled by changes of the series-parallel connections of the traction motors, the starting resistors and the field shunting resistors. These resistors are used for rheostatic braking also.

ELECTRICAL EQUIPMENT

Pantograph

There is one pantograph of the spring raised type for each unit and it is used for both A.C. and D.C. It has a simple grounding switch on its frame so that the trolley wire can be directly grounded in an emergency.

Air blast breaker

Type : CB 102 ; Rated voltage : A.C. 24 kV, D.C.

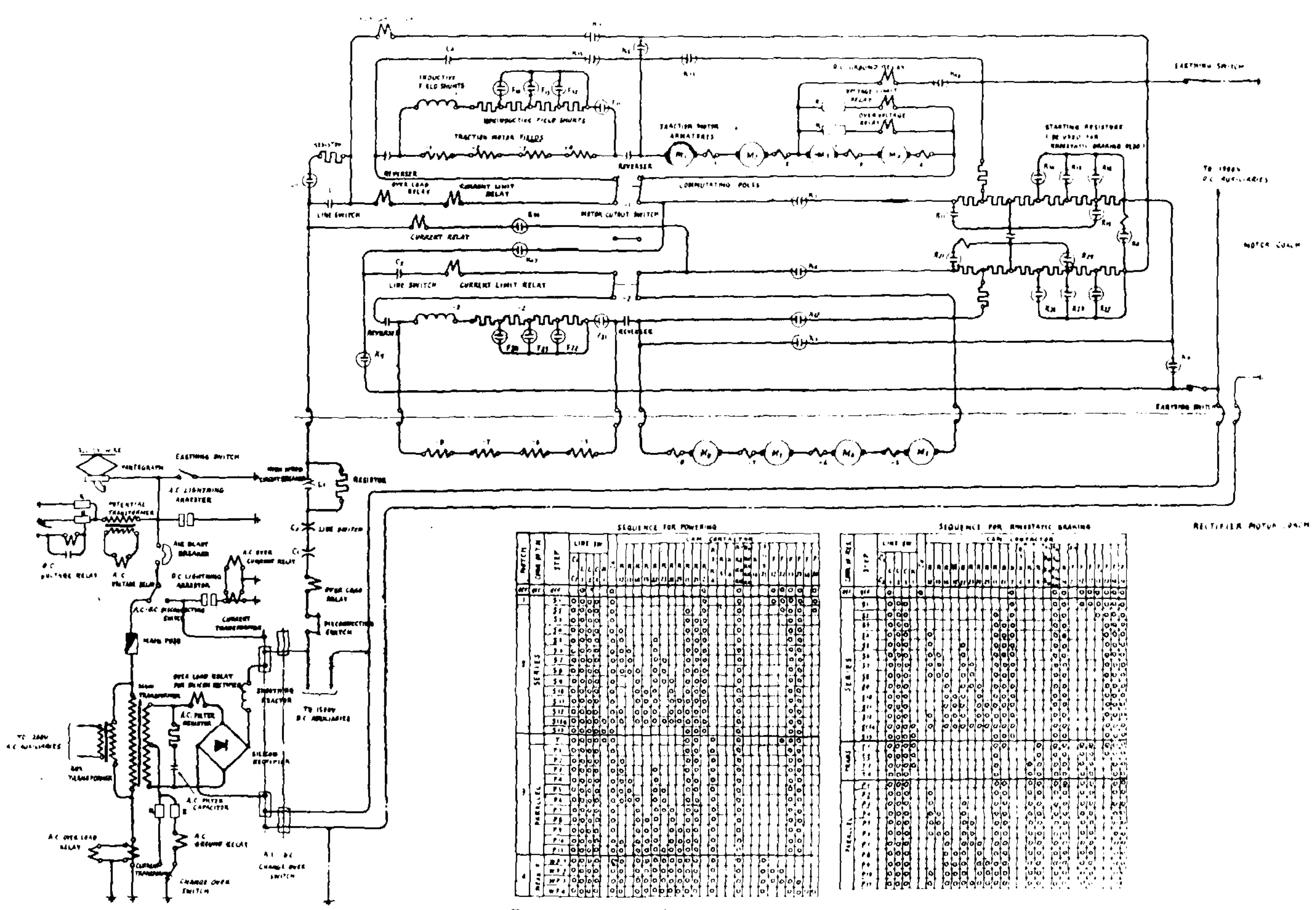


Fig. 9. Schematic Diagram of Power Circuit

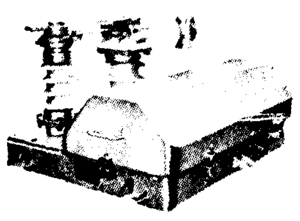


Fig. 10. Type CB 102 Air Blast Breaker

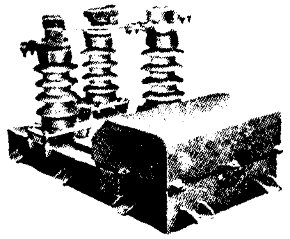


Fig. 11. Type SH 1400 HC D.C. Disconnecting Switch

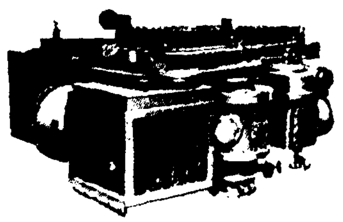


Fig. 12. TM-2 Main Transformer

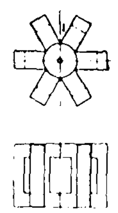


Fig. 13. Structure of Radial Core

1,500 V ; Rated current : A.C. 200 A, D.C. 600 A ; Rupturing capacity : 100 MVA, 50 cycles ; Rupturing time : 0.06 sec.; Rated air pressure : 7 kg/cm².

Fig. 10 shows the outside view of this air blast breaker. The operating mechanism is accommodated in a waterproof case for installation on the roof. Structurally, it can sufficiently withstand repeated use.

A.C.—D.C. Disconnecting Switch

Type : SH 1,400 ; Rated voltage : A.C. 23 kV, D.C 1,500 V ; Rated current : A.C. 200 A. D.C. 800 A Rated air pressure : 5 kg/cm.² Intended for installation on roof, the operating mechanism is accommodated in a waterproof case. *Fig. 11* shows its external appearance.

Transformer

Type : TM-2 ; Continuous rating : 807 kVA/800 kVA, 20 kVA/1,820 V ; Auxiliary transformer : 7 kVA 20 kV/210 V, 50 cycle ; Insulation oil ; non-inflammable oil "Hitafunen".

The main transformer is of the so-called radial core type. As shown in *Fig. 13*, yokes are arranged radially around the core. Both the primary and secondary windings are wound concentrically with the core. The contents of this transformer are placed in a round oil tank. The insulating oil is force circulated. Thus the core, windings and tank assume concentrically located cylindrical forms. This makes insulation, cooling effect and mechanical strength of the equipment superior to those of other transformers. The space factor of the core is also most excellent as shown in *Table 2*. Since this transformer can be made in small size and weight, it is ideal for use in electric coaches.

Non-inflammable oil "Hitafunen" is used as insulation oil, which has excellent electrical and physical characteristics. " Hitafunen " itself and its gas are non-explosive and barely inflammable. It is chemically stable and has considerable resistance against oxidization. Thus there is little change in its properties, and this oil can maintain its qualities for years.

Special consideration was given, in the manufacture of this transformer, to sound and vibration shielding because of its use in electric coaches. The core is made completely secure. The magnetic flux density was selected to reduce vibration. Vibration damping rubber is used in installing it in the coach.

Silicon Rectifier

Type: F-4 B; Rated capacity : 810 kW D.C. 1,350 V. 600 A continuous, 1,100 A 30 sec. Connection : 1-phase bridge. Element : Max. allowable P.I.V. 700 V Max. allowable transient impulse : 900 V. Max. allowable forward current : 200 A.

TABLE 2.

Comparison of Space Factor for Each Type of Core Based on Internal Area of Coil

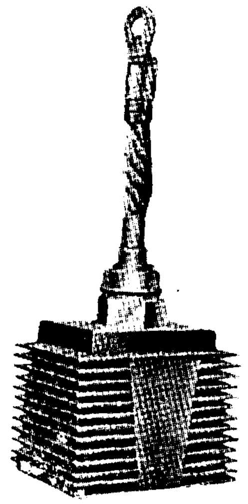
Type	*Space Factor*
Outside Core Type	0.74—0.76
Inside Core Type	0.74—0.82
Radial Core Type	0.84—0.9

The silicon rectifier is ideal for use in electric coaches because of its high efficiency, simple construction and lightweight, and it requires almost no maintenance.

In the silicon rectifier, the elements are a drastic improvement over elements hitherto used. As a result, the number of elements has been reduced to only 80, thereby making it possible to considerably reduce the overall size and weight.

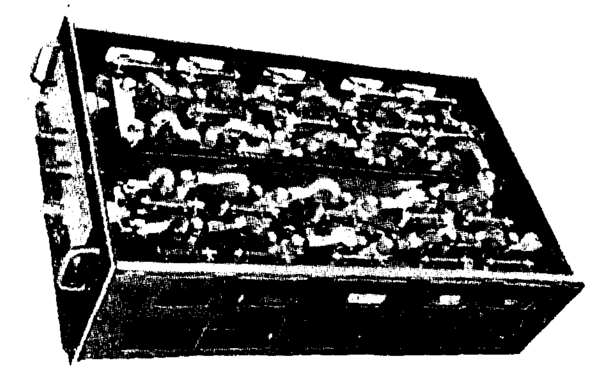
Diffusion type silicon semi-conductors are used as rectifying elements. Progress in the manufacturing process has resulted in elements of high efficiency. Improvement is noted particularly in the inverse voltage rating and there is a considerable increase in current capacity. Of particular advantage in electric coach service is the ability to withstand repeated overload.

Fig. 14 shows the rectifying element and *Fig. 15* the tray combined with elements. *Fig. 16* shows the external appearance of the rectifier box, inside which there are 8 trays and various protective devices.



←*Fig. 14. Cell and Fin*

Fig. 15. Rectifier Tray



Prior to making a decision to adopt the silicon for these coaches, it was subjected to a strict peak load test, short period load test, intermittent load test and mechanical vibration test. As a result, it was confirmed that the equipment was sufficiently strong to withstand these tests.

Traction Motor

Type: MT-46 B; One hour rating: 100 kW, 375 V, 300 A, 1,800 rpm (70% field).

The traction motor is operated by pulsating current in the A.C. section. Therefore, a motor with special consideration for pulsating current is used for these coaches.

Due to the use of the Cardan driving system with a flexible shaft and disc, the traction motor, weighing only 735 kg, can attain a maximum speed of 4,320 rpm minimum field of 40%. Capable of withstanding operation at pulsating current of 30 to 50% current ripple, the motor is assured of excellent performance and good commutation. "A" class and "H" class insulation are used in the armature and field coils, respectively.

Fig. 17 shows the outside view of the traction motor.

Auxiliary Rotating Equipment

Like the traction motor, the 20 kVA motor-generator set and 6 kW motor compressors for the A.C. and D.C. dual system are supplied with power from the 1,500 V D.C. source. They are designed for use with pulsating current. The auxiliary motors for the silicon rectifier and main transformer cooling, to be used in the A.C. section only, are single phase condenser motors which are confirmed to be capable of meeting voltage variations of + 15 – –20%.

A.C.–D.C. Changeover Switch Box

The switch box accommodates a Type KS 6 D.C. 1,000 A continuous A.C.-D.C. changeover switch for switching over the traction motor circuit and auxiliary circuits from A.C. to D.C. or vice versa, together with protective relays, auxiliary relays and pilot lamp. *Fig. 18* shows the interior view of this changeover switch box.

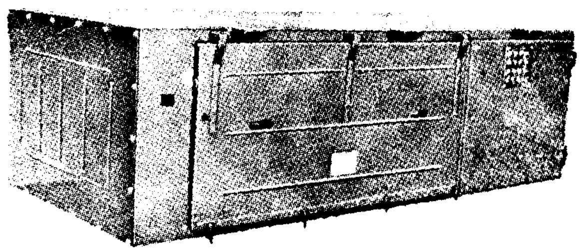


Fig. 16. Cubicle of Rectifier

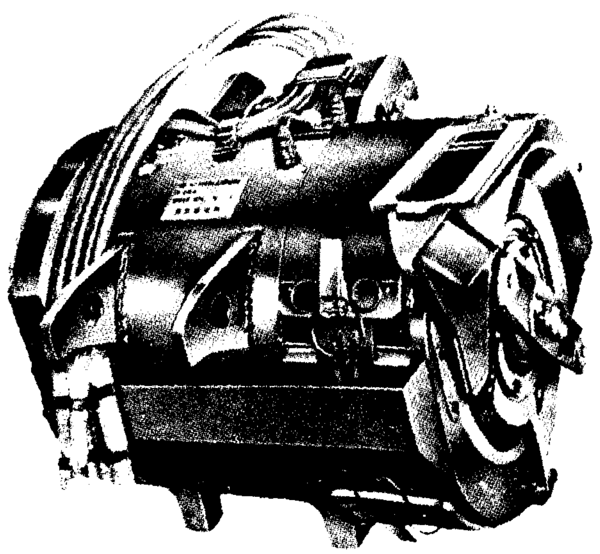


Fig. 17. Type MT 4613 100 kW Traction Motor

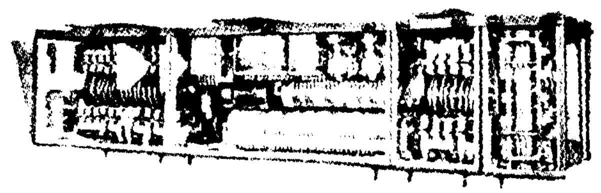


Fig. 18. A.C.-D.C. Changeover Switch Box

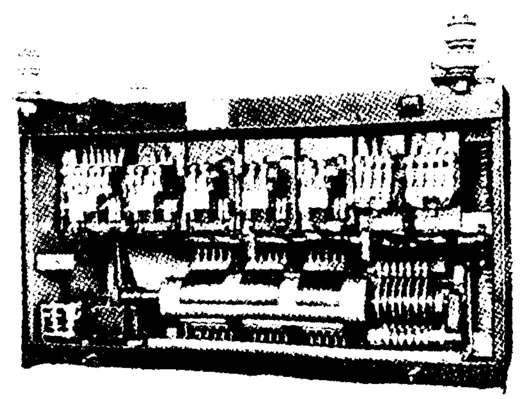


Fig. 19. Type CS 12B Motor Operated Cam Shaft

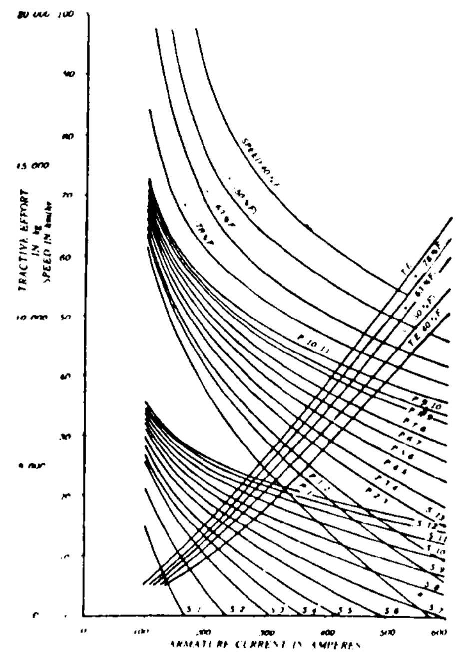


***Fig. 20.** Notching Curves for A.C. System Line Voltage A.C. 18kV c/s*

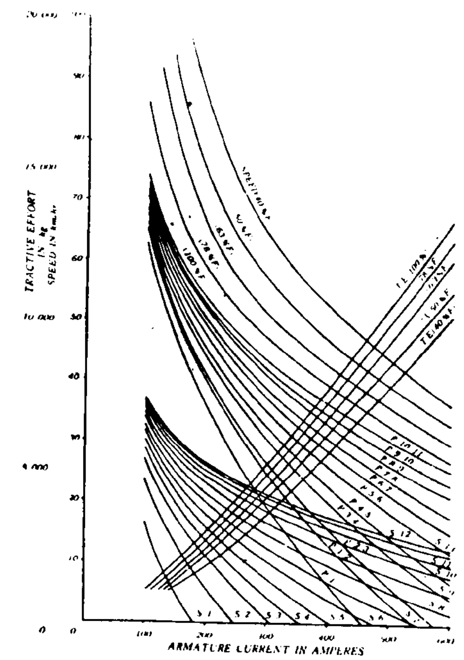


***Fig. 21.** Notching Curves for D.C. System Line Voltage D.C. 1350 V*

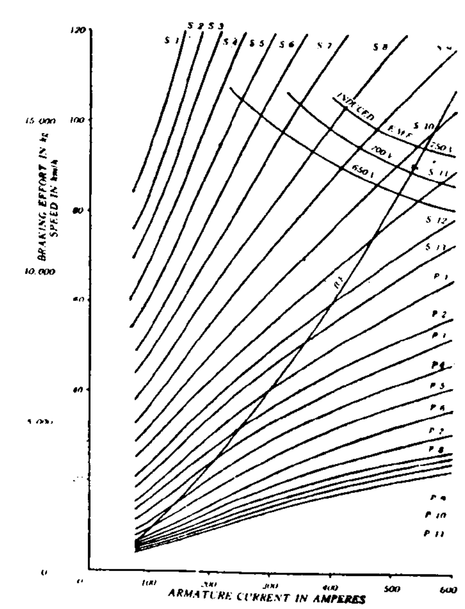


***Fig. 22.** Notching Curves for Pheostatic Braking*

Main Controller Box

This controller box is a modification of the motor operated cam shaft controller, which has been used in J.N.R's D.C. electric multiple unit trains including MOHA 100 and those developed later, for use with pulsating current. *Fig. 19* shows the appearance of type CS 12 B main controller box.

Figs. 20–22 show the notching curves.

Traction Motors for I.C.F.

India's need in respect of generators, transformers, and switchgears will be met entirely by the Heavy Electricals Plant at Bhopal after the Third Plan period, it is learnt. The other two heavy electricals, plants, will be commissioned before the end of the Third Plan with Soviet and Czechoslovakian aid.

Four hundred electric multiple units which are expected to be produced at the Integral Coach Factory Perambur, during the Third Plan period, will be supplied with traction motors and other electrical equipment manufactured at the Bhopal Plant.

This year's production of transformers, switchgears capacitors etc., will be worth Rs. 3.5 crores and next year Rs. 9.5 crores. The factory will start production of heavy industrial motors upto the maximum horse power of 2,000 in 1961 and motors upto 5,000 horse power in 1962. In October 1962 the factory will begin manufacturing hydro-turbines and generators.

* * *

Consultants for Steel Foundry at Chittaranjan

Mr. F. N. Lloyd, chairman of F. H. Lloyd & Co. Ltd., of Wednesbury, Staffordshire, accompanied by three members of his firm, will arrive in New Delhi on January 24, 1962.

F. H. Lloyd & Co. are the consultants to the Indian Railway Board for the steel foundry being set up at Chittaranjan, West Bengal. The firm is also helping in the training of Indian personnel to manage and supervise the foundry, which will produce steel castings needed for locomotive manufacture at Chittaranjan.

Before proceeding to Chittaranjan to see the progress made at the foundry, Mr. Lloyd and his colleagues will attend the Republic Day celebrations in New Delhi.

F. H. Lloyd & Co. is an old-established firm of steel-founders and engineers, producing steel castings of all kinds weighing from a few pounds to 30 tons for many industries, including shipbuilding and railways.

* * *

Modern Trend of Train Lighting

By S. H. Raj, M.E. (Tokyo), M.I.E.E. (Japan)

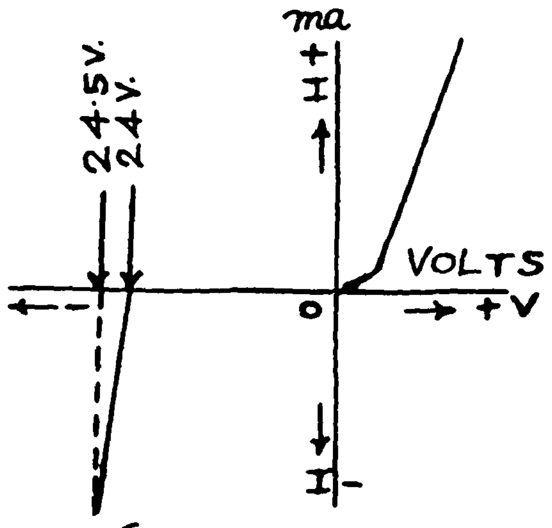
THE present practice of lighting the coaches in the trains in our country is by incandescent lamps and their supply is from a 24 volts D. C. system. This supply is made available by a generator operating in parallel with a battery placed under the bogies. Illumination from incandescent lights are now getting rather obsolete because of their efficiency as well as their distribution of illumination being very low compared with the fluorescent or other mercury vapour lamps.

In all the advanced countries like the United States and Japan the train lighting is done by fluorescent lamps. But these lamps require a minimum voltage of 80 to 100 and preferably of an a.c. supply to avoid the darkening of the tube on one side. So, the generator supplying power for lighting and other appliances in the coaches are mostly alternators in these countries which are of the self-excited type. In addition generation by alternators eliminates the difficulties of commutation and radio frequency interference which are inevitable in d. c. generators. Now that India has started different factories to manufacture coaches for trains in her railways, it is high time that this method of power generation for lighting is adhered to in these coaches.

When the trains are operated by an electric traction system, the incoming supply is always available which drives the motors for the alternators for lighting and other purposes and so there is no necessity of any high power standby supply by batteries. The generation here is of 100 volts or above and the motors and the generators are compensated for the load fluctuations to run at a constant speed and a constant voltage respectively, by suitable feedback controls. But in the case of diesel locomotive or steam locomotive driven trains the generators are driven from suitable belt drives from the wheels of the bogies. So, only when the generator reaches a definite speed, it will be in a position to supply the power at the required voltage and so a standby supply is absolutely necessary in this case. These standby supplies are the 24 volt batteries and the generator is also rated at 24 volts. A section of this generation is directly rectified and connected in parallel with the batteries and the remaining portion is stepped up to the required voltage of 100 or above and fed to the fluorescent lighting. Below a certain speed when the generator is cut out the lighting supply is taken from the batteries and fed to the incandescent lamps that are placed at some regular intervals in between the fluorescent lamps. In advanced countries the stopping time at the platforms of stations are so limited that the capacity of the standby supply need not be very heavy whereas in India this time is so high but the author hopes that this will be gradually reduced in due course.

In the case of the former kind of generation, the alternator has to be compensated only for load variations by its feed back controls whereas in the latter case it has to be compensated both for the speed and load variations. Or in other words, in the latter case the feed back control should be frequency and load compensated. To keep the reference constant in such a control as well as to keep the gain of the detector circuit reasonably high, is really a problem with the designers of this feedback control. The author has written two papers already on this subject which were published in the November 1960 and August 1961 journal of the Institution of Engineers.

In this present paper a more efficient, compact as well as an economic method of feedback control that can be adopted for these alternators is given. In this connection, it should be remembered that as these alternators are increasing in size day by day due to the increase of loads in the coaches, magnetic amplifiers are employed



(FIG. 1).

for the control of the field of the alternators for compensating the fluctuations in load and speed.

With the advent of semi-conducting materials various changes have happened in the control systems of electrical equipments. It is also believed that in due course that the magnetic amplifiers will be replaced by controlled silicon rectifiers but at present the cost of these rectifiers are prohibitive and so the magnetic amplifiers will be retained for some more time to come. But in the detector stage here, a diode which is called a ZENER DIODE is used and its characteristics are given in the Fig. 1. On the positive side this diode behaves just like those of the other semi-conducting diodes whereas on the negative side it takes a very steep slope in the reverse current and the voltage at which the reverse conduction starts can be adjusted in the design of the diode itself. In the case of the 24 volt generation a zener diode which will fire at 24 volts on the negative side will be chosen, if the field coils of the generator are going to be operated at 24 volts. Because of the steep slope at the firing point, the gain of the detector stage is very high and so a low gain magnetic amplifier can also be employed in this case keeping the overall gain constant. Within a voltage variation of 0.5 volts the current conducted on the negative side reaches a very high value and so on no case the voltage across the zener diode should be allowed to exceed 24.5 volts. This is achieved by placing a neon or other discharge tubes which will fire at exactly 24.5 volts in parallel with the zener diode. There might be a tendency of the characteristic shifting due to temperature variation and this shift is compensated for, by placing a Thermistor acro... the Zener diode.

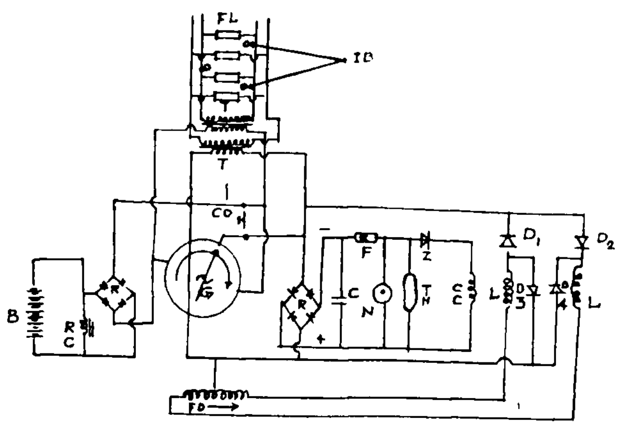


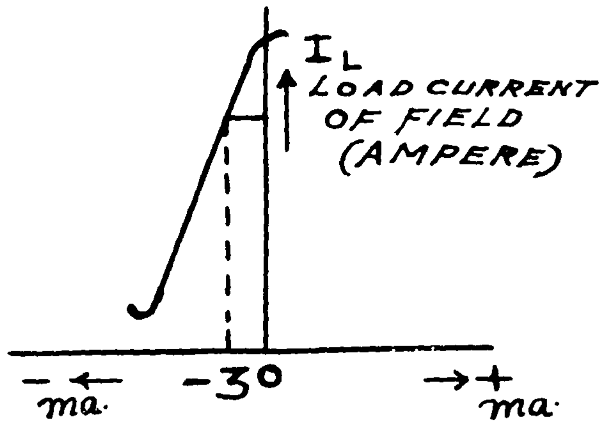
FIG. 2.

PARAMETERS

G	:	Two phase generator
R	:	Full wave rectifer bridges
C	:	Filter condenser
F	:	Replaceable fuse cartridge
N	:	Neon or any limiting tube
TH	:	Thermistor
Z	:	Zener diode
CC	:	Control coil of magnetic amplifier
L	:	Load coil of magnetic amplifier
D1D2	:	Direct load rectifier for magnetic amplifier
D3D4	:	Damper load rectifiers for magnetic amplifier
FD	:	Field coil of generator
RC	:	Relay coil of the cut out
CO	:	Cut Out
B	:	Battery
TT	:	Transformers for the two phases
FL	:	Fluorescent tubes
IB	:	Incandescent bulbs

The above circuit gives the procedure for employing the Zener diode in the control circuit of the magnetic amplifier which is itself in a doubler circuit. Protection is assured by the limiting tube and the fuse cartridge, which can be replaced in case of any surge. The filter condenser takes care of any momentary surges. One phase of the generator feeds the field circuit and the other phase feeds the battery as shown in the figure. In addition both the phases feed the fluoroscent lamps through the transformers alternatively to avoid the flickering effect. Incandescent bulbs are placed at regular intervals and they are fed from the battery source when the generator is cut off line. The relay coil in the battery circuit cuts off the generator when its voltage goes below the prefixed level, through the cut out which are interlinked. At the start, the generator is fed either from the battery or self excited by providing suitable connections.

The performance of the magnetic amplifier is given in the Fig. 3. Due to the high gain in the detector circuit and also the gain in the magnetic amplifier, the whole circuit should be damped in a proper way and this is achieved by the damper diodes in the doubler circuit of the magnetic amplifier. In Fig. 3 the ampere represents the control current and the ordinate represents the load current handled by the magnetic amplifier through the field coils. The reference point is taken here as minus three milli-amperes and the operating zone is rather very limited. If the generator voltage is 24 volts the inverse conduction point of the zener diode should be so chosen such that the voltage drop in the control coil by the reference current is taken into account. If the control current is three milli-amperes as in this case and the control coil resistance is 500 ohms, then the voltage drop in the control coil is 1.5 and so the zener



(FIG. 3.)

diode should be chosen from the 22.5 volt class. Then the protective tubes as well as the thermistor should be correspondingly rated.

When this circuit was actually put into operation the fluctuations were practically zero and the off-set under any varying conditions of speed and load was found less than 0.2 per cent, when recorded in a pen-oscillograph. When the starting is by self excitation the starting time was found less than 2 sec. when the critical speed was reached. Momentary surge during starting conditions occur but these are very quickly damped by the damper circuit and the off-shoot of voltage which exists on the first cycle does not harm the detector circuit as it gets absorbed by the filter condenser. This surge can also be completely eliminated if the battery takes the initial excitation.

This method of self excitation becomes very compact and also very reliable and these are getting introduced very fastly in the advancing countries. But for the magnetic amplifier all the other components are very small and the entire feed back unit is made as a compact feed back control box and mounted on the generator itself. The author has further conducted research to reduce the size of the magnetic amplifiers used in these cases and thereby the overall cost of the feedback control equipment and these are being patented and will be published in due course by him. This research was conducted in Japan and the author feels very grateful for all the assistance given by the coach manufacturers as well as the universities there.

ELECTRONICS IN SIGNALLING

The first electronically-operated system of signal interlocking in the world has been installed at Henley-on-Thames in a British Railways' Western Region signal box.

The equipment is designed to perform the basic function of all railway signalling apparatus by controlling the interlocking of signals so that adequate distances are maintained between following trains or those that could cross or approach each other. It will do this by means of computer-like techniques, using suitable arrangements of plug-in electronic " logic " units in which transistors and magnetic cores perform " logical " switching operations.

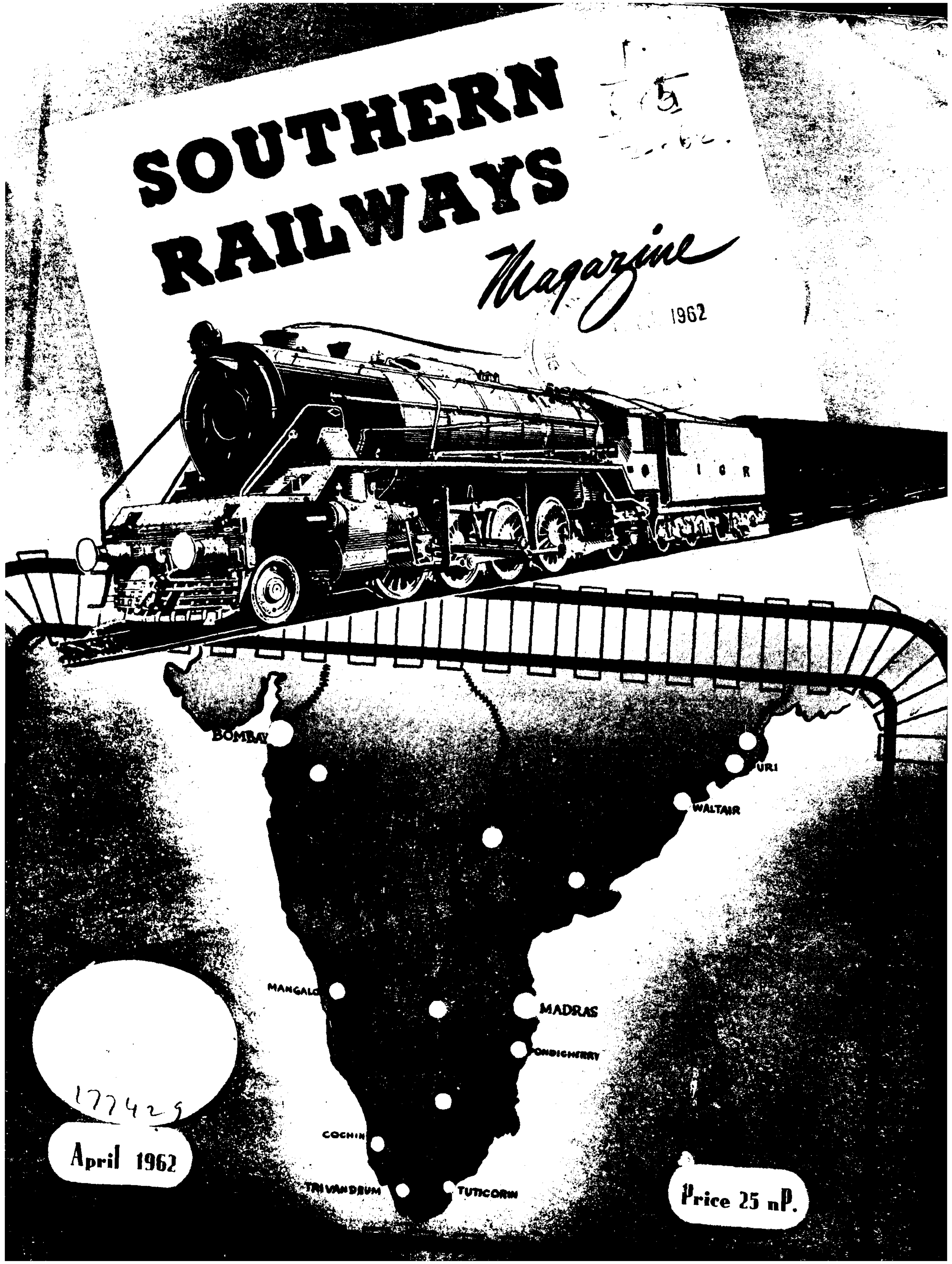
Designed to satisfy British Railways' stringent safety requirements, the system has many advantages. It should substantially reduce long-term maintenance costs and make economies possible in the storage of replacement parts. Signalling installations themselves could be reduced in size, as well as the buildings required to house them. In the present instance at Henley-on-Thames the electronic equipment occupies only one third of the space taken up by the previous manually-operated mechanical interlocking equipment.

To permit the movement of a train, the signalman simply turns a switch representing the point of entry to the required route, and pushes a button representing the exit of the route.

Should the " logic " units of the electronic interlocking system " decide " that the safety requirements for the movement have been proved, then the route can be cleared. All the necessary points can be set and locked in the required direction, and the correct signals will then clear. Any conflicting signals remain at " red ", and in the event of any electronic component breaking down the system will immediately become " fail-safe ", switching all the appropriate signals to " red ".

If the new method now under trial proves as successful as is expected, once the doors of the equipment racks are closed the electronic components should carry on for years without attention.

The scheme is being developed in collaboration with Mullard Equipment Limited.



IN YOUR OWN INTERESTS

HOW TO PURCHASE TICKETS

Buy your tickets only at the proper place. The authorised offices are (i) the Booking offices at the railway stations, (ii) the Town or City Booking Offices, (iii) the Out-agencies, (iv) Travel Agents. Never buy tickets from any other source as that may lead you to trouble. Please note that tickets are not transferable.

Buy your tickets in the proper time. You can avoid unnecessary excitement and trouble if you come to the station in good time, that is at least half an hour before the scheduled departure of your train. The Time Tables of the Railway are on sale at Booking Offices and Bookstalls.

Buy your tickets in the proper manner. Queue up at the Booking Window and you can get your ticket easier and quicker than by crowding at the counter.

By handing in the ***exact fare in good coins or currency*** you get the ticket easier and quicker, and save for yourself and the Booking Clerk time and trouble.

Check up your ticket and money before leaving the counter and draw the attention of the Booking Clerk to any discrepancy you may notice.

(Inserted in the interests of Travelling Public)

Electrify and or Dieselise the Railways in Southern Region

WE are at the threshold of the Third Plan and yet. one does not see any prospect of the Southern Railway attaining greater efficiency, either in clearance of goods traffic or reduction of overcrowding in passenger trains. The reason is not far to seek. The Second Plan included very little expansion and additional facilities. May be, crores had been spent on patch doublings and remodelling of yards and provision of bigger buildings at stations. These essentially are items of greater convenience, but have brought no achievement of quick transport. The slogan as now oft-repeated is the doubling of the line from Jalarpet to Erode and extension of electrification from Tambaram to Villupuram. Of what little avail are these ? On behalf of the intelligent travelling public and the suffering industrialists of South India, an assessment of the situation as obtained is long overdue and we hope to convince in the ensuing paras, the Railway Moghuls seated in the capital of the Government of India, that the solution from all points of view—including the economics of capital and annual working expenditure and operational efficiency—is that the Southern region must be electrified and dieselised.

The new Passenger Time Table has come out on the April Fool's Day and with it the commencement of the second year of the current Third Plan. One will be pardoned for bringing to the notice of the public some items which are of befooling nature, but which the discriminatory Southerner would not swallow. Day in, day out, one hears that the speeds are improved up. A distance of about 70 kilometres between Madras and Arkonam had been working as a double section for many decades. Pacific Locomotive Enquiry Committee Members, including the world famous locomotive expert Mr. Stanier and later, French experts had travelled on the double section with old types of locomotives, attaining during the tests, high speeds of between 65 and 70 miles an hour. To record that the running time of the Bombay Mail from Arkonam to Madras is 105 minutes working out to 0.6 kilometres per minute or 24 miles per hour, is not April Fool's joke. Thank God that in the year 1962, the speed is not much less ! One is fancifully reminded of the days when the Banglaore Express, leaving Madras Central at 13-00 hrs. after a quick lunch, steamed into Bangalore in time for dinner, with a running time of 6½ hours. Powerful locomotives like WPs did not exist then. During the South Indian Railway Company time, one used to get into the Ceylon Boat Mail at about 21-00 hrs. and reach Tanjore near about 4/45 hrs. in the early hours of the morning and reach Tiruchi at twilight. The average speed now on this practically level section is 48 kilometres per hour. equivalent to nearly 24 miles an hour whereas in 1940s, it was nearly 30 miles an hour. The easy explanation that had been offered sometime back was that there had been bunching of trains in Madras Central. This does not apply any more, as Madras Central Station has been remodelled with complete automatic electric signals in Basin Bridge area and for Madras it is in progress. If locals are to run at the same time, surely speeding up is possible by provision of diesel locomotives, which have far better and higher cruising speeds and acceleration and deceleration. Workmen right from Arkonam visit facteries which are fast springing up at Ambattur, Perambur, Tiruvottiyur, to name only a few. Gigantic developments have baen planned by the Defence Ministry. The Defence Ministry, make note, is set for implementation in phenomenal time of its projects. The Defence Minister, by the way, does not believe in too much publicity, but does his part silently. He hates press propaganda methods as are adopted by the Railways. What a halo about frequent reports in dailies about development of the Integral Coach Factory, Remodelling of Madras Central station, turning a sod in Salem area, opening of a bigger station at Cuddalore, Chidambaram, etc. Are these found necessary to counteract the very little that the Railways have done for the South, both of planning and by execution ?

The other day, the General Manager of the Southern Railway lamented aloud that passenger earnings were going down ! If the public is to patronize the Railways, it can only be under conditions dictated by or favourable to them, a seat-cum-sleeper accommodation for every traveller in the lower class and a berth in the Upper class, to be allotted in reasonably short time and not waiting at a queue before the Reservation and Enquiry Offices and cover long distance journeys in reasonably quick time. With crores of rupees that had been sunk as Railway capital in recent years, is it too much to ask that the average speed per hour for Mails and Express trains between important junctions is stepped up to 40 miles per hour and 30 miles per hour for Broad Gauge and Metre Gauge respectively? It would not be far cry if the Railways decide to dieselise/electrify the south. This is imperative from other aspects as well. The speeding up is only incidental. Coal has to come from long leads of nearly one thousand miles from Bengal and Bihar. True, Singareni, nearer south has stepped up production, but this is all required for industries. The coal from Madhya Pradesh and Vindhya Pradesh is totally unfit for locomotives and hence, it is high time that the Railway Board delete this source from their books. Coal is carried to the south by wagons and by mostly old steamers, termed, 'colliers'. Considerable money has been spent to instal mechanised equipment for handling coal at Madras Harbour, but it is not very difficult to switch this over for ore traffic. The reduction in coal movement to the south will release line capacity and wagon capacity for movement of other essential commodities like Cement, Foodgrains and finished products from steel factories which are all concentrated in the North-Eastern area. We see daily in the papers that there is huge accumulation of such products, awaiting allotment of wagons and movement thereafter. Statements by Railway Board on the easing of the wagon situation and the counter-statements by the Steel, Mines and Fuel Ministry regarding accumulation at pit-head are all common features. The public only know that due to shortage of coal, production in cement factories in the south could not be stepped up, though capacity has been developed. Labourers fail to earn higher pay and valuable equipment is not worked to full capacity. So let a radical solution be thought of in a bold and realistic manner.

The North-East lime between Vijayawada and Madras should be dieselised and as second stage, between Bezwada and Waltair. The line capacity is insufficient and taking the average cost of about ten lakhs per mile for doubling, it involves a capital expenditure of thirty crores. The maintenance of track on a coastal line is also costly. With the doubling, it is going to be another 250 miles to be maintained at high cost for the next five years, which would be the minimum time for settling down of the sub-soil ballast, etc. Thereafter, the vagaries of the weather like monsoon, rain and others would contribute greatly to the enormous expenditure for maintaining the track for running trains at high speeds. It would have been a far more economic proposition if powerful diesel locomotives of 2,000 H.P. had been obtained and placed on this line for movement of goods traffic and with less powerful locomotives for passenger traffic. The requirements would have been of the order of not more than 100 locomotives at a cost of about twelve crores. What would then be necessary is to revise track standards and improve the same for running trains to a maximum speed of 75 miles per hour on passenger trains and 50 miles per hour on through goods on single line. Even if this costs about five crores more which is on the liberal side it is economical. For doubling, it would cost the Railways a capital expenditure of 13 to 15 crores and additional maintenance expenditure of nearly two crores per annum, made up of –

(a) the savings in maintenance of additional doubled track ;

(b) increased availability of wagons released from coal loading ;

(c) speedier movement of freight trains which would run between long stretches of important stations hauling heavier loads ;

(d) feeding the industries in the south regularly of their requirements of raw materials, finished products, etc.

The fuel bill of the Southern Railway represents very nearly 25% of the total working expenses. The annual coal expenditure in lakhs, as compared to the other Railways, is of the order given below. For easy comparison, the coal bill has been equated on other Railways, to the same traffic as has been moved on the Southern Railway about two years back :

Railway.	*Annual coal bill in lakhs of rupees*
Southern	1350
Western	950
Central	790
Northern	690
South-Eastern	650
Eastern	580

It can easily be seen from the above that the Southern Railway is paying through its nose almost two and a half times the amount paid by the Eastern Railway, which is situated in the coal area. Apart from the cost of coal, the supply position has always been a matter of great anxiety. During the months of December 1961 and January 1962, the position was so

precarious that even Mail, Express and Passenger trains were late to the extent of 50% in the Southern Divisions. The Expert Committee on Coal consumption on Railways, under the presidency of Shri Karnail Singh, who now holds the No. 1 post of the Railways, specifically pointed out a few years back that "The Madras—Erode section is a fit case for electrification". He also added that electrification is to be undertaken as rapidly as foreign exchange funds permit, preference being given to sections on which high traffic density makes the test an operational necessity.

It is understood that a scheme has been put forward by the Southern Railway for electrification of Jalarpet-Olavakkot main line section of about 210 miles. This section has very stiff gradients of 1 in 70 between Salem and Jalarpet and 1 in 95 between Salem and Erode and sanction has been given for doubling of a length of about 40 miles. Despite the doubling, the line capacity would not be considerably improved, except by double-heading of all goods trains under steam traction, and with banking this means a third power in the stiff section. In the Third Plan, for this purpose, it is proposed to spend about twenty crores on patch doublings, which includes cost of locomotives also. The policy of the Railway Board which has been issued in 1960 is clear, that "As doubling is costly, this may be proposed only as a last resort after the alternative methods of increasing line capacity such as opening of crossing stations, increase of speed of trains, improvements to signalling had been considered". The policy to be now laid is for electrification so that the speeds of trains can be increased, duly justified by the pattern and density of traffic which is offering during the Third Plan.

It is difficult to be convinced that the homing of diesel locomotives in the thickest of the coal area is either economical or inescapable. The transfer of 100 locomotives from Eastern Railway to operate trains between Waltair and Madras would only be the easiest and quickest solution. With the present maximum speeds, there will be a spurt in greater clearances and in about a year or two, with the strengthening of the track for maximum speed of 50 miles per hour for goods trains, the clearances south of Bezwada would burst the targets even in the fourth year of the Third Plan.

The area south of Madras upto Jalarpet and even Coimbatore on the Broad Gauge and upto Trichy on Metre Gauge is ideally suited for electrification. Madras is the pioneer in building up an electricity grid in the South. Neyveli is soon to put into this grid, millions of units of electrical power. The potentiality for further more power from Neyveli and other sources exists. The Madras Grid system has planned to improve the installed capacity in M. W. to the extent of 1630 M.W. against 708 by the end of 1961 and 275 by the end of 1956. The Madras State Government had confirmed some months back that they would be able to give full power supply for the electrification schemes of the Railways. The increase in line capacity is possible with electric traction, the broad reasons being :

(i) electric locomotives have high acceleration and deceleration characteristics. This means, highest speeds can be attained even in small sections :

(ii) due to high factor of adhesion, they haul heavy loads in gradients. They can also start heavier loads from stations which are situated in gradients ;

(iii) the regenerative braking system on electric locomotives provide for safety of running with maximum speeds down the ghat sections.

Apart from the considerable saving of time, due to watering and fuelling, the problem of water shortage which arises during summer—which incidentally is the peak period for maximum movement of traffic—would diappear. (Incidentally, with double-headed trains, the watering problems are far more difficult). From an operational point of view, trains hauled by electric locomotives can be crossed with greater accuracy, avoiding detention to trains. Financially speaking, it has been deduced by experts that the total savings in the annual working expenses would be of the order of five crores for an electrification scheme, to the extent of about 200 miles, in difficult sections as in west of Jalarpet. The electrification would also completely cut out the necessity for doubling, which is not only costly, but difficult for execution in ghat sections as between Jalarpet and Erode. The electrification of the single line on the Metre Gauge up to Villupuram, including area from Salem to Cuddalore, is an easy affair. The electrification of the coastal line may be undertaken at later stages when the traffic warrants the same. One gathers that a scheme has been put forward for the electrification of the single line between Jalarpet and Erode on a priority basis and extension of the same between Jalarpet and Madras. The electrification between Jalarpet and Bangalore is also of easy execution. Thus an integrated electrification scheme is of urgent necessity. It should not entail considerable foreign exchange, as this can be carried out in stages in the course of next five or seven years, building up capacity in the Heavy Electrical Projects which are on hand at present. What is required is a reappraisal of the products to be turned out from them and laying down priorities. There are considerable ancillary services in the south that have developed, as also in the Central and Western India, with whom contracts can readily be entered for 10 to 15 years, for supply of electrical equipment, not only for the initial scheme, but also spares for maintenance and repairs of electric locos and traction lines.

This co-ordination for integrated scheme of electrification in the south, from the Private and Public sector fields is long overdue.

The Broad Gauge line west of Erode and the whole of Madura Division have to be worked with diesel locos. Golden Rock Shops can develop as first stage, the maintenance of these locos, but in later years, manufacture of Metre Gauge Diesel Locos would become a necessity. It has been accepted that concentration of locomotive building in one area is inadequate to meet the requirements of the Southern region below the Vindhya mountains. There is great talent in the South and the building up of a Diesel Loco Factory could be achieved in quick time. The economics of diesel operation, reflected in more naya paisa per mile, is more than offset by the advantages to the industry and the potentiality for development of ancillary industries in the South, offering more employment, particularly in Ramanathapuram, Tinnevelly and Kerala areas. The development of an Iron Ore Plant in Salem area would call for considerable increase in rail transport. With a refinery functioning in Bombay, the movement of diesel oil via Cochin and Tuticorin ports would bring down the cost of diesel operation considerably. With more and more oil find in Western area, dieselisation of the Madura Division and the West Coast broad gauge line would become all the more imperative. This would also release considerable tank wagon capacity for movement into the interior, and also loading capacity from Western India and Hyderabad areas for traffic other than coal, etc.

It is not yet too late to give fresh thinking to this problem of quick and adequate rail transport for the Southern region. A re-appraisal of the requirements of the South for the Third Plan should immediately be made by appointing a High Power Technical Committee consisting of Members from Western Europe and U. S. A. so that practical men who had in recent years engaged themselves in elaborate change-over from steam to diesel and electric power, could give a working scheme spread over a period of five to seven years, for completion by the middle of the Fourth Plan. The Committee should be given the freedom to apportion the workload as between Private and Public sector, with a view to limiting the foreign exchange to the minimum and programming of the development of the ancillary industries in the electrically-minded South for maintenance and repairs of electric stock and for building and maintenance of diesel locos and apportion priority works for the Heavy Electrical Projects, or an ancillary to the same in the South.

The Indian Railways began electrification for the first time in 1925 with 1500 V. D. C. for 240 miles in the Bombay and Madras regions. Later, with 3,000 V. D. C., they extended it for 90 miles in Calcutta region. In 1957, the single phase industrial frequency system had been decided upon in electrification programme included in the Second Five Year Plan. This programme contemplated electrification of about 869 miles to cover the following sections: Durgapur to Mughalsarai; Asansol to Rourkela, Khargpur to Dangoaposi via Tatanagar, Tambaram to Villupuram and Calcutta city region.

The first single phase locomotive was put on trial in Rajkharsawan-Dangoaposi section in December 1959 for a length of 46 miles. The second phase was completed on 22 12 1960 with the inauguration of Asansol-Dhanbad section. Let the South, which is already the leader in Electricity production and distribution, have its due quota of quick and adequate transport without any more dilly-dallying. Let India, through the South, lead in Dieselisation Electrification of Transport and be on a par with other countries, at least in the thinking part of it, though not to a gigantic scale, in radical reforms of Regenerative Transport.

Welding News

CAST-IRON WELDING

The Fontargen E 116 electrode, one of a range of low-heat, metal-joining products, has been designed for difficult welds on grey and alloy cast-iron, for welding these metals to steel, and for surfacing and re-building cast-iron where maximum bond-strength and freedom from cracking are required. The electrode has a core of nickel-iron alloy and the coating has been developed to give good flow and bonding properties even at low amperages.

Recently, design changes required a 1½-ton cast-iron bedplate to be reinforced. This was successfully carried out by welding-in a 1½-in. steel plate cold, using this electrode. No pre-heating of the casting was required.

To obtain the required rigidity, 180 plug groove-and-fillet welds were made. Welding was completed in 6 hr., using an 8-S.W.G. electrode at 140 A. and 28 lb. of electrode was consumed. The total cost was considerably less than that of a new casting.

Further details can be obtained from the manufacturer, Welding Improvements Limited, Lady's Lane, Northampton.

METERING REGULATOR FOR GASES

The Harris Model 92 (multi-stage) regulator, the first of its type to be manufactured in the United Kingdom, measures the flow of industrial gases in cubic feet per hour. Cheaper and more robust than the comparable regulator-flowmeter combination, it also possesses the advantage that its accuracy is not affected by the angle at which it is fitted to the cylinder. Unlike ordinary pressure regulators it has a restricted outlet with an accurately-machined bore. By governing the pressure in the outer chamber of the regulator, a measurable amount of gas flows out of the restricted outlet.

Flow remains constant, regardless of changes in cylinder pressure, so that all the gas is used. Neoprene valve seats and diaphragms in the second stage have been incorporated as a safety factor.

Further details can be obtained from the manufacturer, British Industrial Gases Limited, 700 Great Cambridge Road, Enfield, Middlesex.

SILVER BRAZING ALLOYS

Five Fontargen silver brazing alloys have been developed for specific needs. A.300 is a brazing alloy containing about 4 per cent silver, it has a bonding temperature of about 750 deg. C., and a working temperature of about 870 deg. C. A. 307 is a silver brazing alloy with a bonding temperature of about 570 deg. C., and a working temperature of 630 deg. C. A.310 is a silver brazing alloy with a bonding temperature of 560 deg. C. and a working temperature of about 620 deg. C. It is a quasi-eutectic alloy for use where a very small melting range is required. A.311 is a sliver brazing alloy with a bonding temperature of 650 deg. C. and a working temperature of about 710 deg. C. It is cadmium free and is valuable for food and drink preparation for this reason. A.312 is a silver brazing alloy with a high silver content and additions of nickel and manganese. It is in foil form containing a thin central lamination of copper giving the joint remarkable elasticity. It is produced for brazing hard metal inserts to give high bond strengths. All these alloys have tensile strengths of 22 to 25 tons per sq. in. Further details can be obtained from the distributors for the U.K. and Eire, Welding Improvements Limited, Lady's Lane, Northampton.

WELDING RECTIFIER

The CVR200 constant-voltage selenium-plate direct-current rectifier has been introduced for CO_2 welding. It is a 3-phase natural-air-cooled constant-voltage transformer rectifier providing a voltage range of 14 to 30 volts d.c. and a continuous output of 200 amp. d.c. at 25 V. (5 kW.) with an input of 415 V. Fine voltage selection is provided in 16 steps, ensuring accurate voltage control to meet any arc characteristic.

Two selector switches give the required voltage: one for coarse, and one for fine, selection, allowing steps of approximately 1 V.

A feature of the CVR200 is the special variable stabiliser which gives a smooth arc characteristic and provides any added inductance required to minimise spatter loss.

The rectifier is of all-welded construction, is mounted on 5-in. hard-rubber wheel castors and has all panels except the front removable without disturbing the wiring. A special version is available which combines the CVR 200 with a Sprite CO_2 welding unit mounted on a turntable on top of the CVR200. This unit provides a CO_2 welding unit which is completely mobile and fully flexible in operation for high-speed production welding. Further details can be obtained from the Sales Department, Lincoln Electric Co. Ltd., Welwyn Garden City, Hertfordshire.

(Courtesy: "THE RAILWAY GAZETTE")

The Effect of Tamping Work on Sleepers

THE condition of the Permanent Way changes continually and not uniformly and therefore has to be corrected sooner or later according to the speed of traffic. The reason for these changes of track condition rests mainly in the different conditions of the ballast bed on the formation (different kinds of material and variable moisture content), also in the varying pressure on the track (different types of vertical or horizontal pressures and blows). Additionally, the ballast bed consolidates, but this is, in comparison to the changes within the formation, comparatively small. This settlement of the formation itself, is naturally an unfavourable influence on the track condition, but is not the subject of this article.

To lessen the changes in the formation caused by the pressure of the sleeper, the possibilities are either to establish a better formation itself or to lessen the specific pressure of the ballast on the formation. The first can only be achieved with high cost, so that improvement can only be reached by a corresponding forming and packing of the ballast itself. It was formerly believed that the distribution of the pressure over a greater base was guaranteed by an even deeper ballast bed. In reality, the width of distribution is dependent on the depth of the ballast bed, on the material and on the relation of the horizontal to the vertical packing and also on the kind of stress. The greater the vertical packing in comparison to the horizontal packing and the bigger the blows, the smaller will be the width of distribution.

During tamping the ballast underneath the sleeper is mostly only vertically packed and pre-stressed. The pressure of the sleeper compacts the ballast under the sleeper to a larger degree than outside this area. If therefore at the beginning the distribution of the pressure took place within the less compacted ballast, this decreases more and more afterwards.

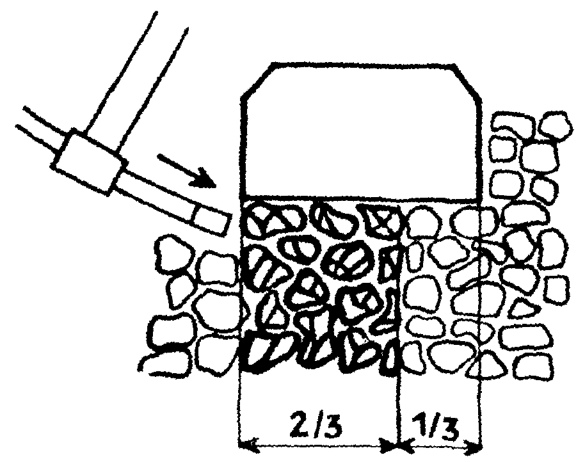
The term "blows" seems to be justified as the weight is in the form of a pressure increasing and decreasing within tenths of a second. The duration of the increase and decrease depends only on the speed of the rolling wheels. But if the ballast bed underneath the sleeper is more solid than the ballast right and left of it, then any pressure in the form of blows will be spread over this more compacted area because of the better conductivity. For instance, shorter or narrower sleepers used instead of normal sleepers show after a short time greater depression with all the unfavourable symptoms (mud joints etc.). A rolled ballast bed has a better effect on the maintenance of a track with wooden sleepers, whereas in the concrete sleeper track the pressure distributing effect of the rolled ballast does not prevail because of the hard blows of the concrete sleepers. Acknowledging this situation a deeper rolled ballast bed is demanded for concrete sleeper track. This has a good horizontal strength and support and is therefore able to distribute the pressure sideways.

Th correction of the cross level is effected by lifting and packing the track by measured packing using chippings. The different methods will be discussed in detail now.

TAMPING BY HAND

First the track is lifted by a track-jack by a predetermined amount, then the existing ballast bed is loosened for better compaction of the ballast, afterwards additional ballast is brought in and then tamped under the sleeper and even every stone individually, until no more can be brought in by normal pressure. By this tamping a consolidation under the sleeper such as in picture No. 1 is achieved. By the direction of tamping and also the relation of the ballast to the shoulder a consolidation is achieved only under the sleeper itself, the compressed part in the ballast bed will not broaden downwards.

When pressure is put on the sleeper after the first tamping, then the whole pressure is conducted over the compacted ballast bed to the track formation. The static pressure cannot distribute itself sideways because in compacted ballast the pressure is lost faster than in the non-compacted ballast bed by reason of the slightly different ballast structure. A pressure in the form of continuous blows seeks much more to find the shortest way of pressure transmission than a static pressure. Within any time period the pressure in compacted ballast travels a far greater distance than in a con-compacted or lesser compacted ballast bed. Therefore the effect on the track



← *not consolidated* *Picture No. 1*

Consolidated

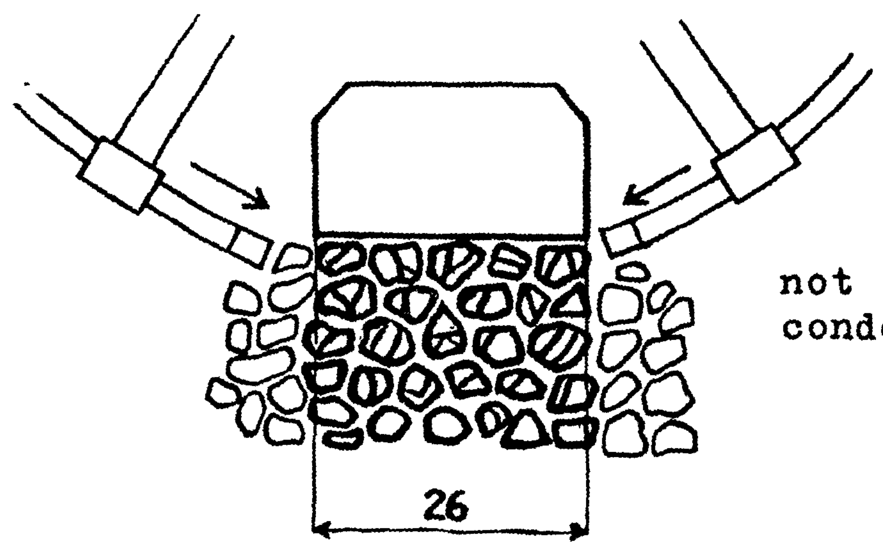
formation is as if the compacted ballast column is directly upon it. Now estimating that the sleeper is 26 cm wide and will be tamped on each side of a rail and a pressure of 8 tons for about 80 cm then a track formation pressure of

$$s = \frac{16.000}{2/3 \cdot 26 \cdot 2 \cdot 80} = 5{,}3 \text{ kg/cm}^2$$

is the result. The track formation pressure is very high and the track formation itself cannot stand it and it gives way and the compacted ballast column collapses. If the tamping lasts for any time at all, then it is only because of the slow speed of some of the trains that these pressures have not an immediate effect. In addition, lower axle loads often reduce the above track formation pressure. A single hand tamping therefore lasts only for a short time. So it is customary in track maintenance to tamp twice. The result according to picture No. 2 is then achieved, which means that the sleeper is sitting on the compacted ballast bed.

The subsoil pressure will be therefore by a uniform compaction

$$s = \frac{16.000}{2 \cdot 26 \cdot 80} = 3{,}85 \text{ kg/cm}^2$$



Picture No.2

not condensed

= condensed

Hand tamping is never uniform, therefore a compaction according to Picture No. 2 will never be achieved. The formation pressure will therefore lie between 3,85 and 5,85 kg/cm, but closer to 3,85, by good double hand tamping. On the average it can be estimated that it will be near 4,5. This relatively high track formation pressure has the effect that more and more ballast is pressed into the formation until a compaction of the track formation is effected.

SPOT TAMPING WITH SMALL MACHINES

By using vibrational or shock tampers the irregularity of the hand tamping is partly avoided.

Because 4 working gangs are necessary for tamping a sleeper, it cannot be uniform. The track formation pressure under the sleepers which are tamped by shock tampers will be between the ideal and the normal hand tamping, that is near 4,3 kg/cm². With vibration tampers a pressure of 4,7 kg/cm² is achieved because of the lower pressure and also the uneven work from each of the four gangs.

MEASURED SHOVEL PACKING

Usually measured packing will be done in tracks which have been tamped before by hand or by means of small spot tampers, and where the track is already compacted by a continuous traffic. By bringing in just a small amount of chippings, the compaction is improved or the ballast bed under this sleeper is more compacted and enlarged. Therefore it can be estimated that the track formation pressure under a sleeper after this work is less than under a sleeper tamped by hand ; it will be about 4,3 kg/cm².

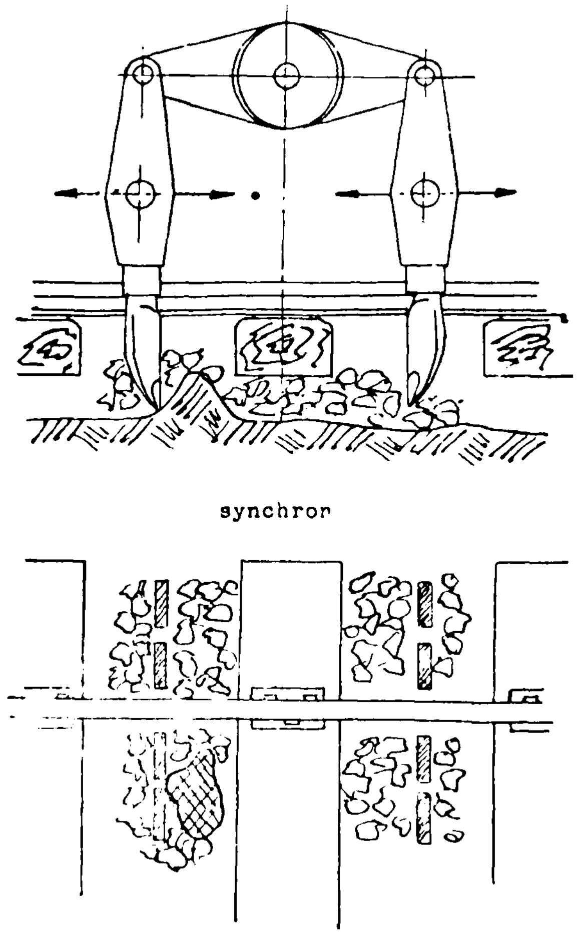
With lifts of more than 20 cm, a non-compacted layer of small ballast would come into existence right underneath the sleeper with the result of irregular settling of the track. The track formation pressure will not change but additional settling will be caused.

TAMPING BY SYNCHRON-CONTROLLED MACHINE

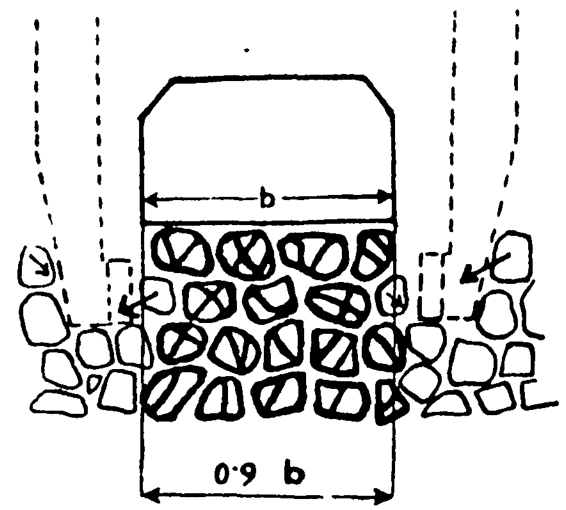
With on-track tampers with synchron-controlled tamping tools the ideal of uniform hand tamping could be achieved. But here with the synchronous machine the tamping is dependent on the track condition which is not always the same for each tool, and therefore the ballast under each sleeper will not receive the compaction which would be necessary to avoid stones falling back into the holes which were left by pulling the tamping tools out of the ballast. This causes a smaller width of the tamped ballast column. In this case the pressure will be conducted over a smaller area to the track formation similar to Picture No. 4. The pressure can be calculated according to this calculation :

$$s = \frac{16.000}{0,9.26.2,80} = 4,3 \text{ kg/cm}^2$$

This shows that tamping by synchron-controlled machines is somewhat superior to the normal tamping by hand.



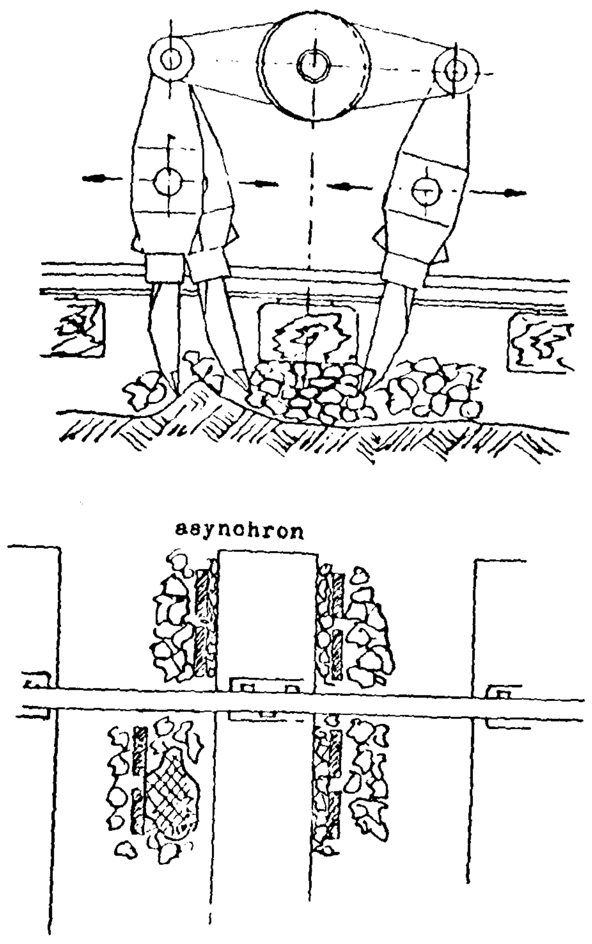
Picture No. 3



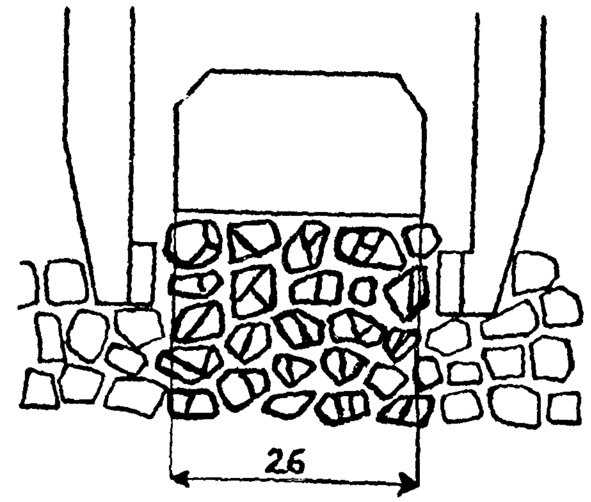
Picture No. 4
= consolidated

THE TAMPING BY NON-SYNCHRON CONTROLLED ON-TRACK TAMPERS

On-track tamping machines of the most modern manufacture finish their work of compaction only after the ballast under the sleeper is compressed by a pre-determined pressure by each individual pair of tools under the sleeper. Therefore the uniformity of this tamping will be superior to the hand tamping and also to the tamping by spot tampers as well as to measured packing, and also superior to the tamping with Synchron-controlled on-track tampers. A compacted ballast column as shown in Picture No. 6 will be between the sleeper and track formation according to the uniform compaction of the ballast. Falling away of ballast will scarcely occur any more. The track formation pressure of such a tamped sleeper will be equal to the ideal hand tamping mentioned at the beginning (track formation pressure 3,85 kg/cm²).



Picture No. 5



Picture No. 6
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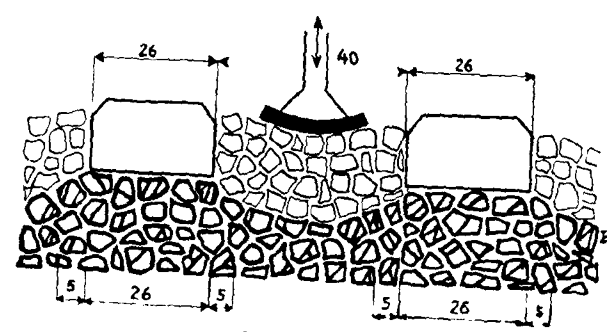
THE IMPROVED NON-SYNCHRON TAMPING BY ON-TRACK TAMPERS

The unfavourable influence of holes caused by lifting the tamping tool was always the object of criticism in railway maintenance, and it was endeavoured to avoid these holes by a second tamping of the ballast between the sleepers. As the ballast between the sleepers cannot move sideways it will be condensed by vertical and also horizontal vibration and is then in the position to distribute the pressure. If we succeed in getting a very strong horizontal compaction of the ballast between the sleepers then a compaction pattern like an inverted arch or vault as shown in Picture No. 7 occurs.

In such a very stiff vault the subsoil pressure would be :

$$s = \frac{16.000}{66.2.80} = 1,5 \text{ kg/cm } 2$$



Picture No. 7

In reality such a vault built from ballast will be elastic so that a pressure in the form of continuous blows will not be conducted to the centre of the wall. If we consider an eighth of the distance between the sleepers as also being a support on each side then the subsoil pressure will be like this : (see Picture No. 7)

$$s = \frac{16.000}{36.2.80} = 2{,}80 \text{ kg/cm } 2$$

If the ballast between the sleepers on one side only of the rails is compacted then the track formation pressure will be :

$$s = \frac{16.000}{36.80 + 26.80} = 3{,}25 \text{ kg/cm } 2$$

After some time the effect of the vault will get lost so that on the average the subsoil pressure of :

$$s = \frac{3{,}25 + 3{,}85}{2} = 3{,}55 \text{ kg/cm } 2$$

can be calculated.

THE EFFECT OF THE TAMPING

The effect of the tamping is dependent on :

(a) The quality of the tamping, that is, the compaction of the ballast ;

(b) on the settlement of the track formation which works contrary to the compaction.

For this article, it was estimated that the quality of tamping for all kinds of tamping were equal, though this is not always true. The quality will be better with the new tampers with greater pressures than with old machines which have only small pressures at their disposal. Then it was supposed that the same kind of soil is always in the track formation. The figures given for the different track formation pressures already show that a certain plastic deformation is caused within the track formation (which do in fact occur).

To simplify the calculation let us assume that the plastic setting changes with the square of the track formation pressure, the following logical conclusion will be reached :

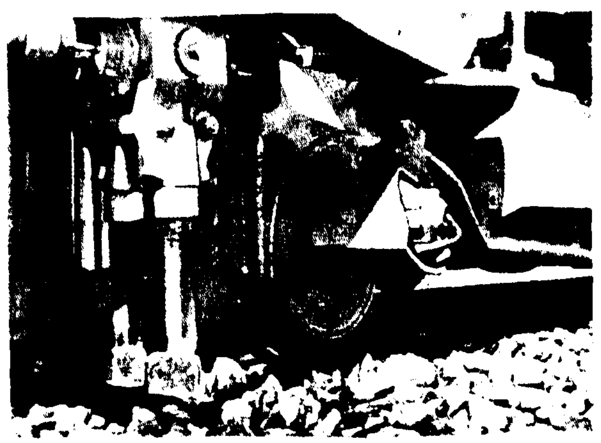
(Continued on page 12)

As the quality of tamping decreases with increasing settlement it must be in indirect proportion to the square of track formation pressure.

A comparison of the different ways of tamping mentioned above is in the following table :

Method of Tamping	Subsoil Pressure s in kg cm 2	Effect in comparison to the double hand tamping
1. Hand tamping (single)	5.3	72
2. Hand tamping (double)	4.5	100
3. Tamping by Vibration	4.7	90
4. Spot Tamping	4.3	110
5. Measured Packing	4.3	110
6. Machine Tamping synchron controlled	3.85 4.3	120
7. Machine Tamping non-synchron controlled	3.85	135
8. Improved non-synchron controlled Machine Tamping (with compaction of ballast between the sleepers outside of the rails)	3.55	160

The above estimation shows that for instance (see 8.) the improved non-synchron controlled



Picture No. 8

A BUSY YEAR AT ROLLS-ROYCE

DEVELOPMENT OF ENGINE WITH FOUR-VALVE CYLINDER HEAD

IN November 1960, Rolls-Royce exhibited a 'Mark IV' version of the well-known 'C' range of diesel engines. The new engine is now commercially available in the turbocharged form for operators and builders to whom an especially high power-to-weight ratio is important. The extra power has been obtained by the introduction of four valves per cylinder, an arrangement permitting a freer gas flow. Individual cylinder heads and gaskets are fitted in the Mark IV engine.

Fifty Mark IV eight cylinder turbocharged engines are now in course of delivery to the Swedish builders, Kalmar Verkstads A. B. for new shunting locomotives for the State Railways. A further twenty six-cylinder horizontal turbocharged units are being delivered to power Jamaican Railway Corporation railcars built in England by the Metropolitan-Cammell Carriage and Wagon Company Limited.

Although the Mark IV engines are now more in the limelight, Rolls-Royce are still supplying substantial numbers of the well-tried two-valve-head engines, in both horizontal and vertical types. Early in 1961, British Railways placed a repeat order through Drewry Car Company for forty 180 hp horizontal engines for railcars. Engines of this type were first delivered to British Railways in 1957, and on the busy suburban services of the North East Region, they are running for a period of 200,000 miles between overhauls.

The first diesel-hydraulic shunting locomotives commissioned by British Railways are also at present entering service. They are compact Rolls-Royce powered Yorkshire Engine Company locomotives of 176 hp. with the power equipment installed at an inclined angle.

(Continued on page 15)

Picture No. 9

machine tamping will be better by 25% than the commonly used machine tamping. Better in this sense that the tamping will last longer. The compaction of the ballast between the sleepers has another great advantage, i. e. resistance against a shifting of the track is increased and the danger of track distortion therefore decreases.

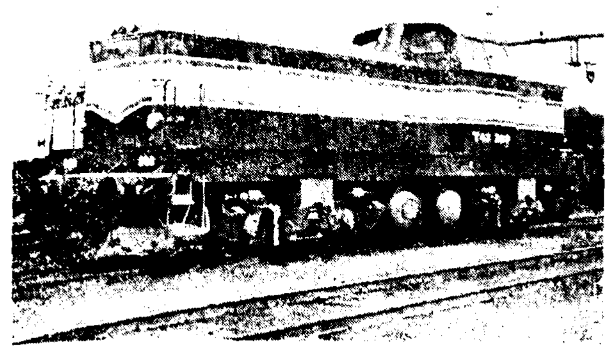
The improvement is obtained because 2 vibrators are mounted to the usual track tamping machine, and these adjustable vibrators are in turn fitted to a longer lever arm. Simultaneously with the tamping the following crib is compacted on the outside of the rails (Picture No. 8 and 9) by these vibrators. The vibrator are suspended and adjustable and make 2800 vibrations per minute, driven by an electric motor. By the weight of the vibrators, together with the vibrations the ballast within the crib is compacted and made like an arch or vault.

CONCLUSION

The continuous variations of the top of the track are caused mainly by depression or settlement of the formation. These settlements again are caused by the high pressures underneath the sleeper. The pressures reach such high values because a pressure distribution in the ballast bed can scarcely occur, as a result of the compaction of the ballast underneath the sleeper caused by the continuous impact of the traffic. The figures of the formation pressures are estimated, and a suggestion is made as to an improvement in the effect of machine tamping. The improvement is achieved by consolidation of the ballast between the sleepers.

T43 - Swedish State's Latest Locomotive

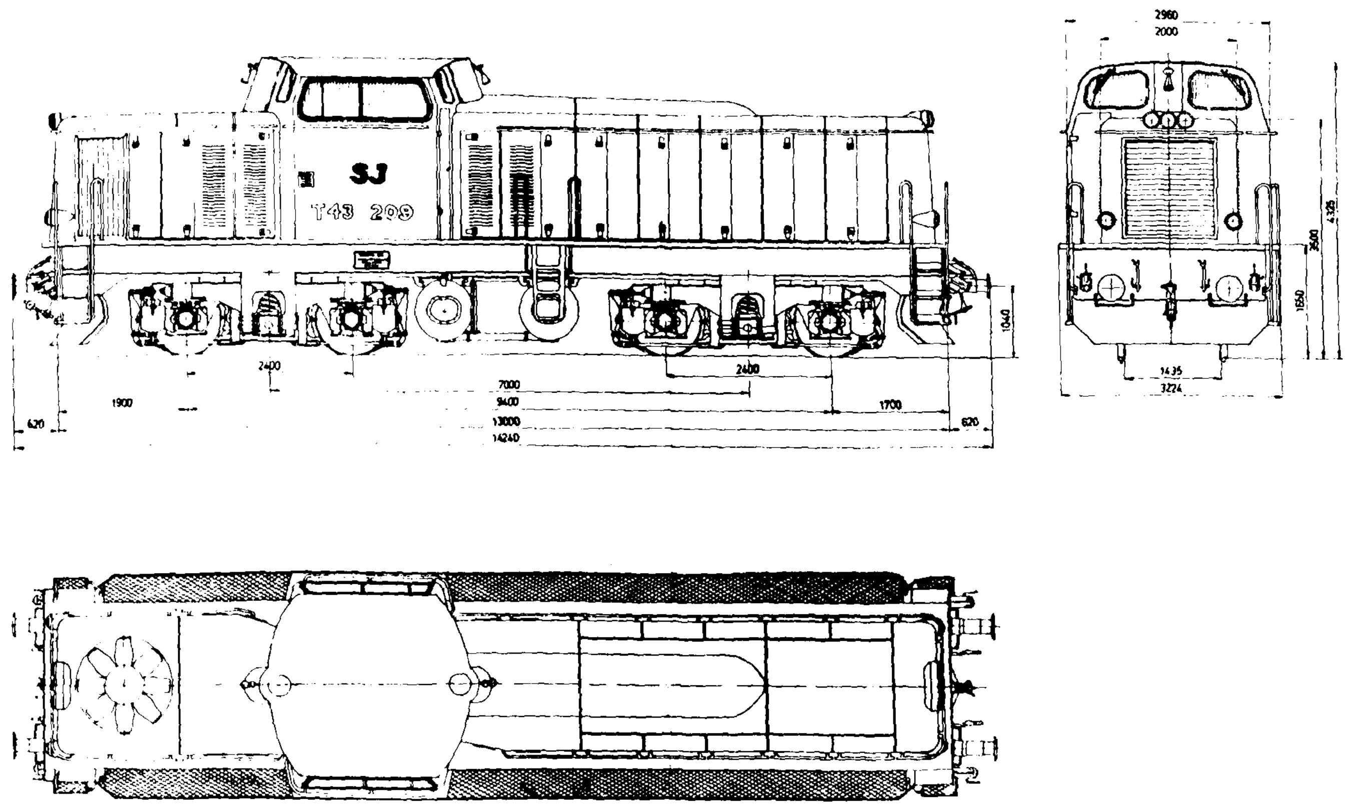
THE State Railways in Scandinavia have taken delivery of diesel-electric locomotives manufactured by NOHAB, Trollhattan, in collaboration with General Motors, USA.

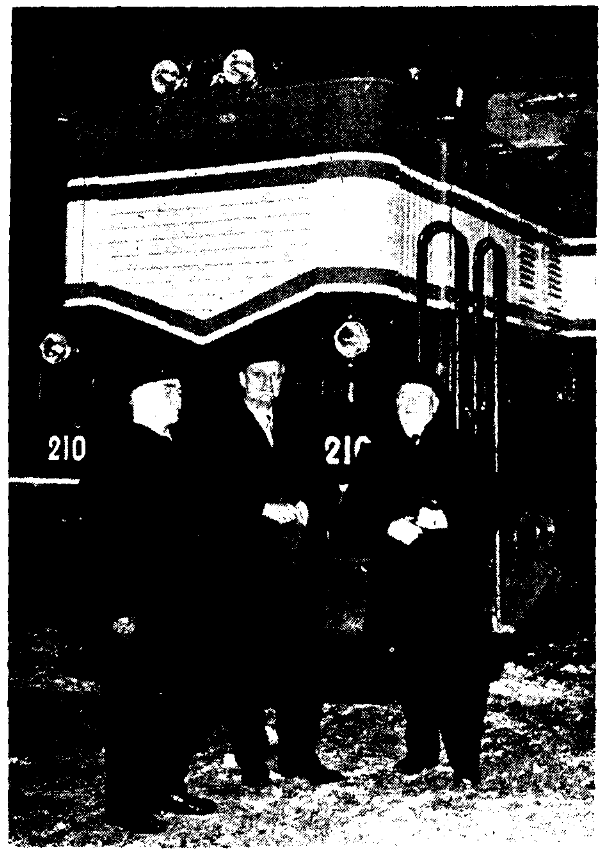


The new NOHAB-GM diesel-electric locomotive, class T43, just before the delivery.

Thanks to the good operation results obtained by the first NOHAB-GM locomotives. The Swedish State Railways have favoured NOHAB with repeat orders and a series of 50 locomotives is now under production in the shops. These are designated T43 and have the following principal data :

Gauge	1435 mm
Axle arrangement	B—B
Length over buffers	14240 mm
Overall wheelbase	9400 mm
Bogie wheelbase	2400 mm
Maximum height	4325 mm
Maximum width	3224 mm





Three General Directors inspecting the new T43 locomotive. From the left: Mr. Erkki Aalto, Finland, Mr. Erik Upmark, Sweden and Mr. H. E. Stokke, Norway.

Total weight (= adhesion weight)	72 tons
Maximum axle load	18 tons
Maximum output of diesel engine	1425 HP at 835 rpm.
Maximum speed	95 km/h

The T43 is powered by a GM diesel engine, developing 1425 HP at 835 rpm. The main generator and the traction motors are being manufactured by the Swedish company ASEA. Maximum tractive effort on starting is 21,600 kg.

The cab is laid out for one-man operation. The forward hood accommodates the diesel engine, generator, compressor and brake apparatus. The rear hood contains the 8-cyl. auxiliary diesel and electrical apparatus.

The introduction of the T43's will substantially reduce the operation of steam locos in Sweden. Steam locomotive operation mileage will be cut from 233,000 to 69,000 locomotive metr. miles. The State Railways have completed a plan which covers the distribution of T43's throughout the system. They will be used for both passenger and freight haulage.

AEI DIESEL ELECTRIC LOCOMOTIVES FOR NYASALAND

Associated Electrical Industries announce that its Traction Division has just received an order for eight 1200 h. p. diesel electric locomotives from the Nyasaland and Trans-Zambesia Railways.

The mechanical parts of these single-cab 81 ton Co-Co locomotives will be made by Metropolitan-Cammell Carriage and Wagon Company, Limited at their Birmingham Works. The diesel engine will be the Sulzer Type 6 LDA 28 B. This engine is being used extensively on British Railways Type 2 locomotives and 233 of them are being supplied with AEI electrical equipment: the main traction generator is similarly based on the same AEI generator used on these Type 2 locomotives. The traction motors are of the latest AEI Type 253, a force ventilated motor with an extremely high power/weight ratio, achieved largely by the use of silicone insulating materials. Once again this motor is the same as that being currently supplied for the 57 Type 2 locomotives recently ordered by British Railways. Motors and Generators will be made at the Sheffield and Rugby Works of AEI and the control gear in their Trafford Park, Manchester Factory.

These 3′ 6″ gauge locomotives will be used for hauling freight on the steep grades of the Nyasaland Railways, reaching 1 in 44 with a maximum altitude of over 3800 ft. The top speed of the locomotives is scheduled at 50 m. p. h. and initially they will operate on the 335 mile stretch between Dondo, near the port of Beira in Mozambique, and Blantyre in Nyasaland.

All eight locomotives will be delivered in 1963.

(Continued from page 11)

OVERSEAS ACTIVITY

A temporary pause in the modernization programme of British Railways has enabled British manufacturers to concentrate on the growing markets overseas where industrialization calls for an efficient transport system. The tradition linking British locomotives with early railway developments in many continents is being maintained—maintained with great effort in face of fierce international competition.

Rolls-Royce recognize that some countries who formerly bought all their machinery abroad are now in a position to manufacture for themselves and prefer to do so when large quantities are involved. In such cases they often find a readiness to consider local manufacture under licence. This has happened in the case of the company's Dart turbo-prop aero engine which is entering production with Hindustan Aircraft Limited.

NEW LOCOMOTIVES

Two new Rolls-Royce powered locomotives, both diesel-hydraulic types, which have appeared since this time last year are worthy of mention. Last October the new Sentinel 0–6–0 48 ton industrial shunting locomotive entered service. Externally the locomotive is very similar to the popular 0–4–0 type with its low bonnet line and all-round visibility over the buffers. The standard 0–6–0 unit has a maximum tractive effort of 29,300 lb. and a maximum continuous speed of 18 m. p. h.

In April of this year, Yorkshire Engine Company's long-awaited 600 hp. Taurus locomotive was shown for the first time and handed over to British Railways for trial working. Its transmission principle, now known as 'Type S', was illustrated. An unusual feature of the locomotive is its ability to give an initial tractive effort of 45000 lb. from only one of its two 300 hp. engines. Apart from heavy shunting duties, however, the Taurus was also designed for trip working on main lines, and has a top speed of 36 m. p. h. with both engines driving. Further technical details of these locomotives may be obtained from the manufacturers concerned or from the Railway Traction Department of Rolls-Royce Limited in Shrewsbury, England.

LIAISON

The Railway Traction Department of the company is willing to investigate and engineer complete power installations for customer's individual needs. It deals in virtually all railway power requirements for railcars, surface and underground locomotives, cranes, and generating equipment. A Newsletter describing the department's activities is published from time to time and is circulated free-of-charge to interested railway parties throughout the world. Copies may be obtained direct from the Railway Traction Department in England or through the company's distributors Messrs. William Jacks and Company Limited, who have offices in Calcutta, Madras, and Bombay.

Railway engineers travelling in Britain are welcome to visit the Rolls-Royce diesel engine plant in Shrewsbury, and may make arrangements to do so either before or after leaving India.

CLEAN AIR FROM POWER STATIONS

Forty Flue Dust Monitors Ordered from AEI

Two orders covering the supply and commissioning of forty flue dust monitors have been placed with the Electronic Apparatus Division of Associated Electrical Industries Limited by Babcock & Wilcox Ltd. The equipments are to be installed at C.E.G.B. generating stations at West Thurrock and Rugeley—twenty at each site. They are required for the main boiler construction programme.

A dust monitor head will be installed in each induced-draft inlet duct and will without change in velocity measure the dust emission from the dust arresting plant before it enters the main duct and chimney stack. When the dust emitted exceeds the accepted level as determined by the Alkali Inspectorate, a warning device fitted to the equipment will operate a flashing light on the boiler control desk so that the operator can take the necessary action.

A continuous recording of the dust emission will be provided during the operational period of each boiler. The time between cleaning can be as long as or even longer than 15 months.

Manufacturing plant for seamless tubes

By An Engineering Correspondent

ON the basis of a contract, which had been reached in the autumn of 1957 between the Komplex Hungarian Trading Company For Factory Equipment and the China National Technical Import Corporation, by the end of 1960 it was completed the delivery of equipment manufactured in Hungary for the Plant of seamless tubes in Cheng-tu.

Thus the delivery of the biggest plant exported by Hungary has been completed, and even the test operation in the push bench mill was finished by the second part of 1960, and production was started.

The plant designed for an annual production of more than 200 thousand tons of seamless tubes has three tube mills: push bench mill, medium pilger-Mill, large Pilger-mill.

Hungary delivered the complete machinery of the three tube mills as well as the whole machinery of the common hydraulic engine-house and of the mercury rectifier station of the three tube mills.

The supply of the Pilger roll turning lathes also belonged among the duties of the Hungarian party. The Push Bench Shop is suitable for the manufacturing of seamless tubes of 0 1" to 5 1/4 /33-133 mm/.

As starting material 100—170 mm billets of rectangular cross section are used; these are first cut with shears, then heated, and subsequently calibrated and pierced on a vertically arranged hydraulic calibrating and piercing press, respectively.

The calibrating press is of 460 tons and the piercing press is of 550 tons.

The rolling out of the hollow bodies to tubes is done on the push bench.

The tubes which run out together with the mandrel from the push bench are carried by a rollerway to the reeling mill, which loosens the tubes rolled up on the mandrel; this renders possible the extraction of the mandrel.

After cutting off the bottomed ends of the tubes with a hot saw, they are reheated in a walking beam furnace to the rolling temperature.

To get the final size, the tubes are now fed either into the calibrating mill or into the reducing mill.

The calibrating mill has 8 stands. Here final sizes for tubes of diameters from 2 1/2" to 5 1/2" are given.

The medium Pilger Mill plant is suitable for the manufacturing of 0 4" 0 8 1/2 /102 to 219 mm/ seamless tubes in a maximum length of 28 m.

As starting material ingots having rectangular cross section and corrugated surface are used, which after having been heated in a rotary hearth furnace to the rolling temperature /1250°C/ are pierced on a horizontally arranged hydraulic piercing press to form hollow bottomed bodies with circular cross section.

After reheating the closed-bottomed hollow bodies, they are elongated by the elongator between two shaped rolls adjusted askew; here the bottom which remained after piercing is rolled out too.

The feeding mechanism represents one of the most important part of the Pilger-mill. The maximum stroke of the feeder's hydraulic cylinder is about 8000 mm, while the maximum stroke of the air cylinder is about 1400 mm.

The final size of tubes is ensured also in this case by a 5-stand calibrating mill. The diameter of the rolls is 750 mm and the maximum run-out speed of the tubes is 1.2 m/sec.

GOLDEN RULES OF CONDUCT FOR RAILWAYMEN

1. Do you plan your work daily? Get the more essential things done first and do not neglect the important ones sidetracting them to the fag end of the day.

2. Do not express casually careless opinion. Never venture forth an opinion unless asked for it.

3. Remember that most of our mental worries come either from trying to fight life hard or from trying to run away from life. Do neither.

4. Learn to accept people as they are, love them, respect them, praise them encourage them, differ with them, but above all, learn the priceless art of give and take.

5. Cry neither for the moon, nor over spilt milk.

6. Accept the things that you cannot change; have the courage to change the things that you can, and possess the wisdom to know the difference.

7. Do not drive too hard a bargain with yourself.

8. Accept life as it is — its wonders, changes, disappointments, frustrations etc., etc.

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CLEANLINESS LEADS TO HEALTH AND HAPPINESS

Clean orderly habits contribute to general health and welfare and as such to happiness and prosperity: they are more important than medicines.

Cleanliness prevents disease: medicine only attempts to cure.

Cleanliness of the person, of the houses and colonies, reflects discipline in the individual and the community. Discipline is the foundation stone for progress of oneself and the country. Cleanliness is a good habit. It is also cheap.

All Railwaymen should set an example of cleanliness. This will help others and themselves.

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