REPRINT OF SPECIAL ISSUE. Price 1/-
Vol. 1. No. 5.

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The Engineering Times.

An English Illustrated Magazine.

Edited by BEN H. MORGAN.

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INDICE DEL DIRECTORIO DE "THE ENGINEERING TIMES" PARA LOS COMPRADORES.

Este directorio contiene los nombres y senas de algunos de los ingenieros y fabricantes de mas seriedád, con los artículos especiales que fabrican traducidos al Francés, al Alemán y al Espanol, para uso de los compradores en el extrangero. Los compradores, en el pais y en el extrangero, que deséen tener informes respecto á caulquiera de los artículos y maquinaria detallados á continuación, pueden dirigirse a nosotros y háremos lo posible para procurárselos, sin hacer cargo alguno. Rogamos á todos los que se valgan de este directorio que al hacer sus pedidos ó pedir presupuestos directamente, se sirvan mencionar nuestro nombre.

INDEX DU GUIDE DU "ENGINEERING TIMES" A L'USAGE DES ACHETEURS.

Cet annuaire contient les noms et adresses des principales maisons de constructions mécaniques et etablissements manufacturiers, dont les spécialités respectives, pour la commodité des acheteurs, y sont indiquées en français, allemand et espagnol. Nous ferons tout notre possible pour fournir gratis tous renseignements dont ils auront besoin, sur les machines et marchandises énumérées dans l'Annuaire, à ceux des acheteurs qui se seront adressés à nous. Nous prions tous ceux qui consultent notre Annuaire d'indiquer notre nom s'ils transmettent leurs demandes et ordres directement.

The Engineering Times.

Vol. I. CONTENTS, April-May, 1899. *No. 5.*

Miscellaneous Section.

(See Folio at bottom of Pages.)

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The Engineering Times

COMPLETE

BUYERS' DIRECTORY.

This Directory includes the names and addresses of some of the most reliable Engineering and Manufacturing Firms, and for the benefit of foreign buyers the names of their leading specialities are translated into French, German and Spanish. If home and foreign buyers will communicate with us respecting any of the machinery and goods mentioned hereunder we will do our utmost to supply them, FREE OF CHARGE, with any information they may require, and we ask those who make use of this Directory to kindly mention our name when forwarding enquiries or orders direct.

AGRICULTURAL MACHINERY.—Machines Agricoles.—Ackerbau-Geräthe und Maschinen.—Maquinas Agricolas.

Name and Address.	Telegraphic Address.
Clayton & Shuttleworth, Lincoln	Clayton, Lincoln
Corbett, T., Shrewsbury	Corbett, Shrewsbury
Fowler, J. & Co. (Leeds Ltd.), Leeds	... Fowler, Leeds.
Garrett, R., & Sons, Leiston Works, Suffolk	... Garrett, Leiston.
Howes, S., 64 Mark Lane, London, E.C.	Barbeau, London.
Marshall, Sons & Co., Ltd., Gainsborough	Marshalls, Gainsborough.
Middleton, J.P.	Gee Cross, nr. Manchester.
Richmond & Chandler, Manchester	**Mowers, Manchester.**
Robey & Co., Ltd., Lincoln	... **Robey, Lincoln**
Ruston, Proctor & Co., Ltd., Sheaf Ironworks, Lincoln	... Ruston, Lincoln
Samuelson & Co., Ltd., Banbury, Oxon	Samuelson, Banbury.

AIR AND GAS COMPRESSORS.—Comprimeurs d'Air et de Gaz.—Luft und Gas verdichter.—Kompresore, de Aire y de Gas.

Bailey, W. H. & Co., Ltd., Albion Works, Salford, Manchester ...	... Beacon, Salford.
Clayton, Howlet & Co., Westbourne Park, London, W.	Brickpress, London.
Easton, Anderson & Goolden, Ltd., Erith	Egyptian, London.
Hathorn, Davey & Co., Leeds	... Hathorn, Leeds.
Ingersoll-Sergeant Drill Co., 114A Queen Victoria Street, London, E.C.	
Sandycroft Foundry and Engine Works Co., Ltd., nr. Chester	**Sandycroft, Hawarden.**
Siebe, Gorman & Co., 187 Westminster Bridge Road, London, S.E.	**Siebe, London.**

ANTI-FOULING COMPOSITIONS.—Compositions préservatives contre salissage.—Schiffsbodenansatz-Verhinderungsmittel.—Composicion Anti-Ensuciadora.

Kingfisher Ships' Composition Co., Leeds	**Kingfisher, Leeds.**

BELTING.—Courroies.—Riemen. - Correas.

Angus, Geo. & Co., Ltd., St. John's Works, Newcastle-on-Tyne ...	Angus, Newcastle-on-Tyne.
Fleming, Birkby & Goodall, Ltd., West Grove Mills, Halifax ...	Fleming, Halifax.

Name and Address.	Telegraphic Address.
Frictionless Engine Packing Co., Ltd., Cable Mills, Glasshouse Street, Manchester	**Packless, Manchester.**
India Rubber, Gutta Percha and Telegraph Works Co., Ltd., Silvertown, Essex	Graysilver, London.
Lancashire Belting and Hose Co., Manchester C.	**"Macmechan," Manchester.**
Norris, S. E. & Co., Shadwell, London, E.	Vigilos, London.
Parkes, H. C. & Co., Blue Boar Court, Manchester	Tact, Manchester.
Tullis, John & Son, Ltd., St. Anne's Leather Works, Bridgetown, Glasgow	**Tullis, Glasgow.**
Wallach Bros., 57 Gracechurch Street, London, E.C.	Hammerman, London.
Willcox, W. H. & Co., Ltd., 34 and 36 Southwark Street, E.C.	

BLOWERS AND BLOWING ENGINES.—Souffleurs.—Blasebälge.—Aventadores a Máquinas de Soplar.

Black, Hawthorn & Co., Ltd., Gateshead-on-Tyne	Blackthorn, Newcastle-on-Tyne.
Blackman Ventilating Co., Ltd., 63 Fore Street, London, E.C.	Ventilation, London.
Churchill, Chas., & Co., Ltd., 9-15 Leonard Street, London, E.C.	Opodeldoc, London.
Matthews & Yates, Ltd., Swinton, Manchester	
Samuelson & Son, Ltd., Banbury	Samuelson, Banbury.
Scott, Ernest, and Mountain, Ltd., Close Works, Newcastle-on-Tyne	**Esco, Newcastle-on-Tyne.**

BOILERS.—Chaudieres.—Dampikessel.—Calderas.

Abbot, J. & Co., Gateshead-on-Tyne	Abbot, Gateshead.
Bowman, J. & Co., 19 Nicholson Street, Glasgow	
Cochran & Co., Ltd., Birkenhead	Multitubular, Birkenhead.
Danks, E. & Co. (Oldbury), Ltd., Oldbury, nr. Birmingham	Boiler, Oldbury.
Galloways, Ltd., Manchester	Galloways, Ltd., Manchester.
Grantham Crank and Iron Co., Grantham	Land, Grantham.
Hawksley, Wild & Co., Sheffield	**Hawksley, Sheffield.**
Lees, T. & R., Hollinwood, nr. Manchester	**Lees, Hollinwood.**
Manlove, Alliott & Co., Ltd., Nottingham	**Manloves, Nottingham.**
Oldham Boiler Works Co., Ltd., Oldham	Boilers, Oldham.
Tinkers, Ltd., Hyde, nr. Manchester	Tinkers, Hyde.
Whitehouse, J., Ilkeston	Whitehouse, Ilkeston.

BRASSFOUNDERS.—Fondeurs en Cuivre.—Messing Giesser.—Fundiciones de Cobre

Abbot, John & Co., Ltd., Gateshead-on-Tyne	Abbot, Gateshead-on-Tyne
Asbestos Co., Ltd. (Bell's), 59½ Southwark Street, London, S.E.	Belfry, London
Bailey, W. H. & Co., Ltd., Albion Works, Salford, Manchester	Beacon, Salford.
Carr, Charles, Ltd., Smethwick, Birmingham	Bell, Smethwick, Birmingham.
Smith & Co., Midland Injector Works, Nottingham	**Injector, Nottingham.**
Smith, Sydney, & Sons, Basford Brass Works, Nottingham	Smiths, Nottingham.

BRICK AND TILE-MAKING MACHINERY.—Machines à Briques.—Ziegelei Maschinen.—Maquinaria para hacer ladrillos.

Bennett & Sayer, Derby	Bennett & Sayer, Derby
Bradley & Craven, Westgate Common Foundry, Wakefield	Craven, Wakefield.

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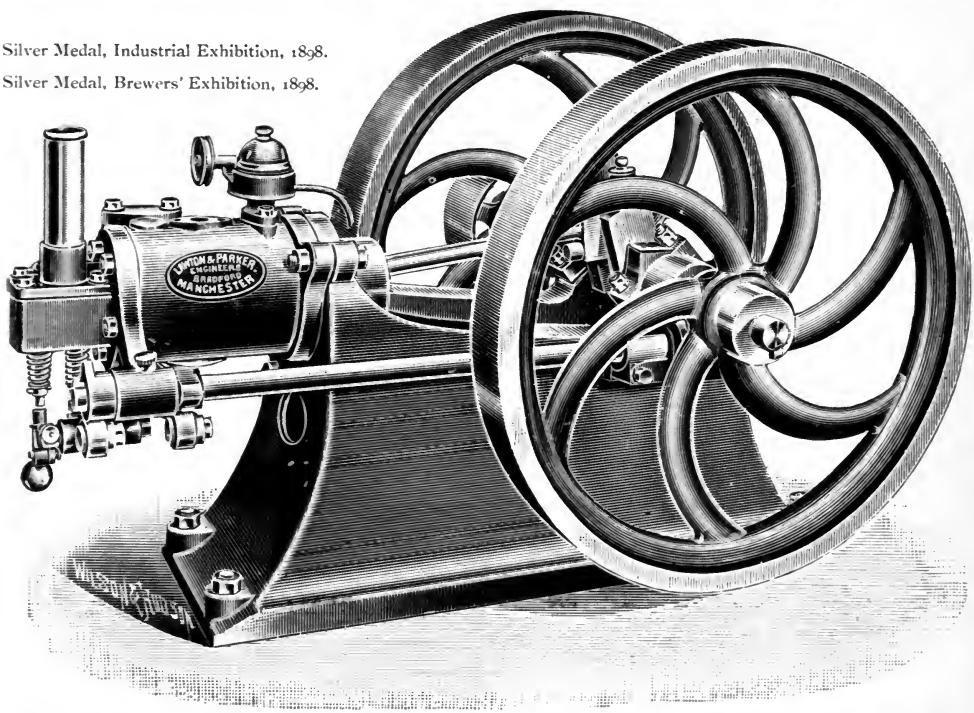

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2	37 0 0	16	116 0 0
3	50 10 0	18	127 0 0
5	63 0 0	20	137 10 0

Name and Address.	Telegraphic Address.
Clayton, Howlett & Co., Westbourne Park, London	Brickpress, London.
Fawcett, Thos. & Co., Ltd., Whitehouse Engineering Works, Leeds	
Johnson, W. & Sons, Castleton Foundry, Armley, Leeds	Ronksley, Armley.
Whittaker, C. & Co., Dowry Street Ironworks, Accrington	Bricks, Accrington.

CASTINGS, IRON AND STEEL.—Fontes.—Guesstücke, Eisen und Stahl.—Fundiciones de Hierro y Acera.

Abbot, John & Co., Ltd., Gateshead-on-Tyne	Abbot, Gateshead.
Askham Bros. & Wilson, Ltd., Sheffield	Askham, Sheffield.
Bessemer, Henry & Co., Ltd., Sheffield	Bessemer, Sheffield.
Cammell, Chas. & Co., Ltd., Sheffield	Cammell, Sheffield.
Handyside, A. & Co., Ltd., Britannia Works, Derby	Handyside, Derby.
Hunter & English, Bow, London, E.	Venator, London.
Jessop & Sons, Ltd., Brightside Works, Sheffield, England ...	Jessops, Sheffield.
Piggott, Thos. & Co., Ltd., Springhill, Birmingham	Atlas, Birmingham.
Weardale Iron & Coal Co., Ltd., George Yard, Upper Thames Street, London, E.C.	Weardale London.

CRANES.—Grues.—Krahne.—Gruas.

Bedford Engineering Co., Bedford	Cranes, Bedford.
Fielding & Platt, Ltd., Gloucester	**Atlas, Gloucester.**
Grafton & Co., Bedford	Grafton, Bedford.
Joicey, J. & G. & Co., Newcastle-on-Tyne	Engines, Newcastle-on-Tyne.
Leeds Engineering & Hydraulic Co., Providence Works, Cross Stamford Street, Leeds...	Pump, Leeds.
Owen, Brazil, and Holborow, Vulcan Iron Works, Bristol	**Hydraulic, Bristol.**
Pickerings, Ltd., Globe Elevator Works, Stockton-on-Tees	**Pickerings, Ltd., Stockton-on-Tee**
Vaughan & Son, West Gorton, Manchester	Vaunting, Manchester.

CRUSHING AND GRINDING MACHINERY.—Machines à Broyer.—Quetsch und Mahlmaschinen.—Máquinas para Polvoriza y moler.

Baxter, W. H., Gelderd Road, Leeds	**Knapping, Leeds.**
Bradley Pulverizer Co., 34 Clement's Lane, Lombard Street, London, E.C.	Wygo, London.
Cocks, W. E., Bassingbourne Ironworks, nr. Royston, Cambs. ...	Cocks, Bassingbourne.
Mason Bros., Brandon Street, Leicester	Breaker, Leicester.
Richmond & Chandler, Manchester	**Mowers, Manchester.**
Southgate Engineering Co., Ltd., New Southgate, London, N. ...	Centrifugal, New Southgate.

DRILLING MACHINES.—Machines à Percer.—Bohr Maschinen.—Maquinas de Agugerear.

Addy, Geo., Waverley Works, Sheffield	Milling, Sheffield.
Archdale, James & Co., Manchester Works, Birmingham	Archdale, Birmingham.
Churchill, Charles, & Co., Ltd., 15 Leonard Street, London, E.C....	Opodeldoc, London.
Green, J. & Nephew, Cudbear Street, Leeds	Green, Nephew, Leeds.
Niles Tool Works Co., 39 Victoria Street, London, S.W.	

Name and Address.	Telegraphic Address.
Nottingham Engineering Co., St. Albans Street Works, Radford, Nottingham	Iron, Nottingham.
Taite, Howard & Co., Ltd., 63 Queen Victoria Street, London, E.C.	Taite, Carlton, London.
United States Metallic Packing Co., Soho Works, Bradford	**Metallic, Bradford.**

ELECTRICAL MACHINERY.—Machines Electriques.—Electrische Maschinen.—Maquinaria Electrica.

British, Thomson-Houston Co., Ltd., 83 Cannon Street, London, E.C.	Asteroidal, London.
Brush Electrical Engineering Co., Ltd., 49 Queen Victoria Street, London, E.C.	Magnets, London.
Callender's Cable and Construction Co., 90 Cannon Street, London, E.C.	Callender, London.
Electric Construction Co., Ltd., Dashwood House, London, E.C. ...	Concordance, London.
Glover, W. T. & Co., Ltd., Salford, Manchester	Glovers, Salford.
Homes & Co., John, Newcastle-on-Tyne	Holmes, Newcastle-on-Tyne.
Jackson, P. R. & Co., Salford Rolling Mills, Manchester	Jackson's, Manchester.
Johnson & Phillips, 14 Union Court, Old Broad Street, London, E.C. ...	Juno, London.
Mather & Platt, Ltd., Salford Iron Works, Manchester	Mather, Manchester.
Patterson, Cooper & Co., Thistle Works, Paiseley	
Scott, Ernest & Mountain, Ltd., Newcastle-on-Tyne	**Esco, Newcastle-on-Tyne**
Taylor & Challen, Ltd., Derwent Foundry, Birmingham ...	... Derwent, Birmingham
Turner, John & Sons, Denton, near Manchester	Machines, Denton, Lancs.

ENGINE AND BOILER FITTINGS.—Accessoires de Moteurs et de Chaudières.—Maschinen und Kesselausrustung.—Accesorios de Maquinas y de Calderas.

Austen (Beng), 184 St. George's Street, E.	
Asbestos Co., Ltd. (Bell's), 59½ Southwark Street, London, S.E. ...	Belfry, London.
Bailey, W. H. & Co., Ltd., Albion Works, Salford, Manchester ...	Beacon, Salford.
Bennis & Co., Ltd., Lancashire Stoker Works, Bolton	Bennis, Bolton.
Browett, Lindley & Co., Ltd., Patricroft, Manchester	Sandon, Patricroft.
Clay Cross Co., near Chesterfield	**Jackson, Clay Cross.**
Hawksley, Wild & Co., Sheffield	Hawksley, Sheffield.
Kingfisher Patent Lubrication Co., Leeds	**Kingfishers, Leeds.**
McPhail & Simpsons, Ltd., Wakefield	Simpson, Wakefield.
Meldrum Bros., Atlantic Works, City Road, Manchester	**Meldrum, Manchester.**
Owen, Brazil & Holborrow, Vulcan Ironworks, Bristol	Hydraulic, Bristol.
Pillatt, A. & Co., Furnace Engineers, Nottingham	
Pollock, McNab & Highgate, Shettlestone, Glasgow...	Highgate, Shettlestone.
Stewart, D. & Co., Ltd., London Road Iron Works, Glasgow ...	Stewart, Glasgow.
Wallach Bros., 57 Gracechurch Street, London, E.C....	Hammerman, London.

FORGINGS.—Fer Forgé.—Schmiedestucken.—Forjadura.

Clarke's Crank & Forge Co., Ltd., Patent Crank Works, Lincoln	Cranks, Lincoln.
Darlington Forge Co., Ltd., Darlington	Forge, Darlington.
Hadfield's Steel Foundry Co., Ltd., Hecla Works, Sheffield ...	Hadfield, Sheffield.
Leeds Forge Co., Ltd., Leeds	Vulpes, Leeds.

FRICTION CLUTCHES. - Embrayages à Friction.—Friction. - Frictionskuppelungen. – Manguitos de friccion.

Name and Address.	Telegraphic Address.
Bagshaw, J. & Sons, Ltd., Victoria Foundry, Batley	**Bagshaw, Batley.**
Bridge, D. & Co., Friars Works, King Street, Salford, Manchester	
Harpers, Ltd., Aberdeen	Harpers, Aberdeen.
Shore, T. & Sons, Albion Foundry, Hanley	Shores, Engineers, Hanley.
Walker Bros., Pagefield Ironworks, Wigan	Pagefield, Wigan.

GAGES.—Manomètres.—Lehren.—Monometros.

Moncrieff, John, Perth, Scotland	Moncrieff, Perth.
Schäffer and Budenberg, 77A Queen Victoria Street, London, E.C.	Pyrometer, London.
Wallach Bros., 57 Gracechurch Street, London, E.C.	Hammerman, London.

GAS ENGINES.—Machines à Gaz.—Gas Maschinen (Motoren)—Motores a Gas.

Bilbie, Hobson & Co., 80 Queen Victoria Street, London, E.C.	Andrew, London.
Blackstone & Co., Ltd., Stamford	**Blackstones, Stamford.**
Campbell Gas Engine Co., Ltd., Kingston, Halifax	Camgas, Halifax.
Crossley Bros., Ltd., Manchester	Crossleys, Openshaw.
Cundall, R. & Sons, Ltd., Shipley, Yorks	Cundall, Shipley.
Fielding & Platt, Ltd., Gloucester	**Atlas, Gloucester.**
Furnival & Co., Reddish Iron Works	
Green, J. & Nephew, Cudbear Street, Leeds	Green, Nephew, Leeds.
Lawton and Parker, Openshaw, Manchester	

HYDRAULIC MACHINERY.—Machines Hydrauliques.—Hydraulische Maschinen.—Maquinas Hidraulicas.

Abbot, John & Co., Gateshead-on-Tyne	Abbot, Gateshead.
Berry, Henry & Co., Croydon Works, Hunslet, Leeds	Rivetter, Leeds.
Easton, Anderson & Goolden, Ltd., 3 Whitehall Place, London, S.W.	Egyptian, London.
Fielding & Platt, Ltd., Gloucester	Atlas, Gloucester.
Middleton, Robt., Sheepscar Foundry, Leeds	**Hydraulic, Leeds.**
Mills, Edwin & Son, Aspley Iron Works, Huddersfield	**Omo, Huddersfield.**
Owen, Brazil & Holbrow, Vulcan Ironworks, Bristol	Hydraulic, Bristol.

INDICATORS.—Indicateurs.—Indikatoreu.—Indicadores.

Ernest, Scott & Mountain, Ltd., Newcastle-on-Tyne	**Esco, Newcastle-on-Tyne.**
McInnes, T. S. & Co., Ltd., 41 Clyde Place, Glasgow	Indicator, Glasgow.
Schäffer & Budenberg, 77A Queen Victoria Street, London, E.C.	Pyrometer, London.

LATHES.—Tours.—Drehbanke.—Tornos.

Addy, Geo., Waverley Works, Sheffield	Milling, Sheffield.
Archdale, James & Co., Manchester Works, Birmingham	Archdale, Birmingham.
Churchill, Charles, & Co., Ltd., 15 Leonard Street, London, E.C.	Opodeldoc, London.
Green, J. & Nephew, Cudbear Street, Leeds	Green, Nephew, Leeds.
Nicholson Tool Co., Newcastle-on-Tyne	**Machinery, Newcastle-on-Tyne.**
Nottingham Eng. Co., St. Alban's Work's, Radford, Nottingham	Iron, Nottingham.
Richards, Geo. & Co., Broadheath, nr. Manchester	**Richards, Altringham.**
Richardson & Co., Well Lane, Halifax	
Webster & Bennett, Atlas Works, Coventry	**Profile, Coventry.**
Wild, A. M. Sheffield	

ENGINEERING TIMES Buyers' Directory.

LAUNCH AND YACHT BUILDERS.—Constructeurs de Chaloupes à vapeur et Yachts.—Dampfbark assen und Yachten.—Constructores de Lanchas de vapor y Yachtes.

Name and Address.	Telegraphic Address.
Cochran & Co., Birkenhead	**Multitubular, Birkenhead.**
Fleming & Ferguson, Ltd., Paisley, N.B.	Phœnix, Paisley.
Owen, Brazil & Holborow, Vulcan Ironworks, Bristol	Hydraulic, Bristol.
Yarrow & Co., Poplar, London, E.	
Simpson, Strickland & Co., Ltd., Dartmouth, S. Devon	Engineers, Dartmouth.
Thornycroft, J. I. & Co., Chiswick, London, W.	Thornycroft, London.

LOCOMOTIVE ENGINES.—Locomotives.—Locomotiven.—Locomotoras.

Avonside Engine Co., Bristol	Walker, Bristol.
Bagnall, W. G., Ltd., Castle Engine Works, Stafford	**Bagnall, Stafford.**
Fowler, J. & Co. (Leeds), Ltd., Leeds	Fowler, Leeds.
Hudswell, Clark & Co., Leeds	Loco, Leeds.
Joicey, J. & G. & Co., Newcastle-on-Tyne	Engines, Newcastle-on-Tyne.
Peckett & Sons, Bristol	Peckett, Bristol.
Stephenson, Robert & Co., Ltd., Newcastle-on-Tyne	Rockett, Newcastle-on-Tyne.

MACHINE TOOLS. — Machines. — Outils. — Werkzeugmachinen. Herramientas Mecanicas.

Addy, Geo., Waverley Works, Sheffield	Milling, Sheffield.
Archdale, James & Co., Manchester Works, Birmingham	Archdale, Birmingham.
Berry, Henry & Co., Croydon Works, Leeds	Rivetter, Leeds.
Bird, John R., 10 Morrison Street, Kingston, Glasgow	
Churchill, Charles & Co., Ltd., 15 Leonard Street, London, E.C.	Opodeldoc, London
Green, J. & Nephew, Cudbear Street, Leeds	Green, Nephew, Leeds.
Hamer, S. H., Range Lane, Halifax	
Hulse & Co., Ordsal Works, Salford	Esleep, Manchester.
Kendall & Dent, Manchester	Tools, Manchester.
Nicholson Tool Co., Newcastle-on-Tyne	**Machinery, Newcastle-on-Tyne.**
Richards, Geo. & Co., Broadheath, nr. Manchester	**Richards, Altringham.**
Samuelson & Co., Ltd., Banbury	Samuelson, Banbury.
Smith & Coventry, Ltd., Ordsal Lane, Manchester	Gresley, Manchester.
Wild, A. M., Tool Maker, Sheffield	

METALS AND ALLOYS.—Metaux et alliages.—Metalle und Legirungen.—Metales Aleaciones.

Carr, Charles, Ltd., Smethwick, near Birmingham	Bells, Smethwick, Birmingham.
Delta Metal Co., Ltd., 110 Cannon Street, London	Delta, London.
Flockton, Tompkin & Co., Newhall Steel Works, Sheffield	Tompkin, Sheffield.
Magnolia Anti-Friction Metal Co. of Gt. Britain, Ltd., 49 Queen Victoria Street, London, E.C.	Magnolier, London.
Phosphor Bronze Co., Ltd., Sumner Street, London, S.E.	**Phosphor Bronze, London.**

MINING MACHINERY. — Machine pour Mines. — Bergwerks Maschinens. — Maquinas Mineras.—Macchine de Miniera.

Bradley Pulverizer Co., 37 Walbrook, London, E.C.	Equestrian, London.
Bullivant & Co., Ltd., 72 Mark Lane, London, E.C.	Bullivants, London.

PUBLISHER'S ANNOUNCEMENT.—Owing to the excessive demand for the issues of the Engineering Times of December, February and March last, copies can now only be supplied to Annual Subscribers.

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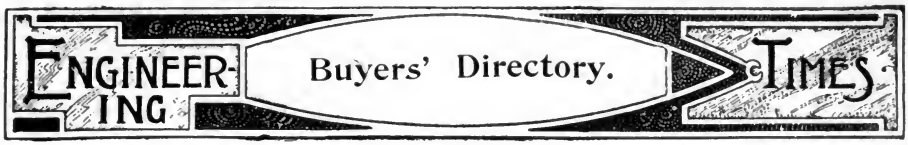

Name and Address.	Telegraphic Address.
Edw. Chester & Co., 120 Bishopsgate Street Within, London, E.C.	Calymene, London.
Gates Iron Works, Dept. K., 150 Dashwood House, London, E.C.	
Hardy Patent Pick Co., Ltd., Sheffield, England	Hardypick, Sheffield
Ingersoll-Sergeant Drill Co., 114A Queen Victoria St., London, E.C.	Enyam, London.
Pulsometer Engineering Co., Ltd., Nine Elms, London, S.W. ...	Pulsometer, London.
Sandycroft Foundry and Engine Works, Co., Ltd., near Chester ...	**Sandycroft, Hawarden.**
Thames Ore Crushing Co., Ltd., Cannon Street, London, E.C. ...	
Waterspout Engineering Co., 1 North Parade, Parsonage, Manchester ...	**Waterspout, Manchester.**

OILS AND LUBRICANTS.—Huiles et Graisses lubrifiantes.—Oele und Echmierfetts Aceites y lubrificantes.

Imperial Steam Users' Association, Hatcham Road, London, S.E.	Valporoso, London.
Kingfisher Patent Lubrication Co., Leeds	**Kingfisher, Leeds.**
Reliance Lubricating Co., 19 & 23 Water Lane, London, E.C. ...	Subastral, London.
Wells, M. & Co., Hardman St. Oil Works, Manchester	Vaseline, Manchester.
Stern Bros., 57 Gracechurch Street, London, E.C.	**Centamoir, London.**
Trier Bros., 19 Great George Street, London, S.W.	Viscosity, London

PETROLEUM ENGINES.—Machines à Petrole.—Petroleum-Maschinen.—Maquinas Petroleo.

Cundall, R. & Sons, Ltd., Shipley, Yorks	Cundall, Shipley
Fielding & Platt, Ltd., Gloucester	Atlas, Gloucester.
Hornsby, R. & Sons, Ltd., Grantham, England	Hornsbys, Grantham.
Priestman Bros., Holderness Foundry, Hull	Priestman, Hull.

PUMPS.—Pompes.—Pompen.—Bombas.

Beaumont's Pump Works, Stockport	Pumps, Stockport.
Drysdale & Co., Bon Accord Engine Works, Glasgow	Bonaccord, Glasgow.
Evans, Joseph & Sons, Culwell Works, Wolverhampton ...	... Evans, Wolverhampton.
Gwynne & Co., Brooke Street Works, Holborn, London, W.C. ...	**Gwynnegram, London.**
Hathorn, Davey & Co., Leeds	
Isler, C. & Co., Bear Lane, Southwark, E.C.	Isler, London.
Joicey, J. & G. & Co., Newcastle-on-Tyne	Engines, Newcastle-on-Tyne.
Merryweather & Sons, Ltd., 63 Long Acre, W.C.	... Merryweather, London.
Owen, Brazil & Holborrow, Vulcan Ironworks, Bristol	Hydraulic, Bristol.
Pearn, Frank & Co., Ltd., Manchester	**Pumps, Manchester.**
Pulsometer Engineering Co., Ltd., Nine Elms Ironworks, S.E. ...	
Siebe, Gorman & Co., 187 Westminster Bridge Road, London, S.E. ...	**Siebe, London.**
Scott, E. & Mountain, Ltd., Newcastle-on-Tyne...	**...Esco, Newcastle-on-Tyne.**
Waterspout Engineering Co., 1 North Parade, Parsonage, Manchester ...	**Waterspout, Manchester.**
Wilcox, W. H. & Co., 34 & 36 Southwark Street, S.E.	Wilcox, Southwark Street, London.
Vauxhall Ironworks Co., Ltd., Wandsworth, London, S.W.... ...	Wellhole, London.

RAILWAY PLANT.—Matériels de Chemins de fer.—Eisenbahn Material.—Material para Ferro-Carriles.

Bagnall, W. G., Ltd., Castle Engine Works, Stafford	**Bagnall, Stafford.**
Birch, John & Co., Ltd., 10 & 11 Queen Street Place, London, E.C.	Endeavour, London.
Dick, Kerr & Co., Ltd., 101 Leadenhall Street, London, E.C. ...	Dicker, London.
Fowler, J. & Co. (Leeds), Ltd., Leeds	Fowler, Leeds.

Name and Address.	Telegraphic Address.
Laycock, W. S., Victoria Works, Sheffield	Invention, Sheffield.
Nottingham Engineering Co., St. Alban's Works, Radford, Nottingham	Iron, Nottingham.
Patent Shaft & Axletree Co., Wednesbury	Shaft, Wednesbury.
Penney, Alexander & Co., 107 Fenchurch Street, London, E.C. ...	Finitimus, London.
Summerson, T. & Son, Darlington	Summerson, Darlington.
White, Richd. & Sons, Widnes	

ROPE TRANSMISSION.—Transmission à Corde.—Seiltransmissionen.—Transmision por Cuerdas.

Bagshaw, J. & Sons, Ltd., Batley, Yorks	**Bagshaw, Batley.**
Bullivant & Co., Ltd., 72 Mark Lane, London, E.C.	Bullivant, London.
Glaholm & Robson, Sunderland	Glaholm, Sunderland.
Ironmongers' Rope Works, Ltd., Brykil Street, Wolverhampton	**Reliance, Wolverhampton.**
Rankin, Richard, Manchester Street, Liverpool	
White, Richd. & Sons, Widnes	

SHAFTING, PULLEYS, AND COUPLINGS.—Arbres, poulies et manchons d'embrayage.—Wallen, Riemscheiben und Kuppelungen.—Arboles, poleas y manguitos de union.

Ashton, T. A., Ltd., 40 Norfolk Street, Sheffield	Ashton, Sheffield.
Bridge, David & Co., Friars Works, King Street, Salford, Manchester ...	
Bagshaw, J. & Sons, Ltd., Pulley, Batley, Yorks...	**Bagshaw, Batley.**
Clark's Crank & Forge Co., Ltd., Lincoln	Cranks, Lincoln.
Cruikshank & Cook, 78 Galbraith Street, Glasgow	Blowers, Glasgow.
Fleming, Birkby & Goodall, Ltd., West Grove Mills, Halifax ...	Fleming, Halifax.
Joicey, J. & G. & Co., Newcastle-on-Tyne	Engines, Newcastle-on-Tyne.
Nottingham Engineering Co., Radford, Nottingham...	Iron, Nottingham.
Owen, Brazil & Holborow, Vulcan Ironworks, Bristol	Hydraulic, Bristol
Pickerings, Ltd., Globe Elevator Works, Stockton-on-Tees... ...	Pickerings, Stockton-on-Tees.

STEAM ENGINES.—Machines à Vapeur.—Dampfmaschinen.—Maquinas a Vapor.

Avonside Engine Co., Bristol	Walker, Bristol.
Broadbent, T. & Sons, Chapel Hill, Huddersfield	Broadbent, Huddersfield.
Browett, Lindley & Co., Patricroft, Manchester	Sandon, Patricroft.
Clayton, Howlett & Co., Westbourne Park, W.	Brickpress, London.
Cochran & Co., Birkenhead	Multitubular, Birkenhead.
Coulthard & Co., Preston	**Coulthards, Preston.**
Fowler, J. & Co. (Leeds), Ltd., Leeds	Fowler, Leeds.
Friedenshal, F., Ribble Engine Works, Preston	Screw, Preston.
Grantham Crank & Iron Co., Ltd., Grantham...	Land, Grantham
Joicey, J. & G. & Co., Newcastle-on-Tyne	Engines, Newcastle-on-Tyne.
Lees, T. & R., Hollingshead, nr. Oldham	**Lees, Holingwood.**
Manlove, Alliott & Co., Ltd., Nottingham	**Manloves, Nottingham.**
Owen, Brazil & Holborow, Vulcan Ironworks, Bristol	**Hydraulic, Bristol.**
Peckett & Sons, Bristol	Peckett, Bristol.
Richmond & Chandler, Manchester	**Mowers, Manchester.**

Name and Address.	Telegraphic Address.
Sandycroft Foundry and Engine Works Co., Ltd., nr. Chester, England	**Sandycroft, Hawarden.**
Scott, E. & Mountain, Ltd., Newcastle-on-Tyne	**Esco, Newcastle-on-Tyne.**
Stephenson, R. & Co. Ltd., Newcastle-on-Tyne	Rockett, Newcastle-on-Tyne.
Turner, E. R. & F., Ipswich	**Gippeswyk, Ipswich.**

STEAM HAMMERS.—Marteaux à Vapeur.—Dampjhammer.—Martillos a Vapor.

Samuelson & Co., Ltd., Britannia Works, Banbury	Samuelson, Banbury.
Whittaker Bros., Ltd., Horsforth, Leeds	Quarries, Leeds.

STEAM PACKING.—Garnitures à Vapeur.—Dampf-Packung.—Guarnicion para maquinaria a Vapor.

Ironmongers' Rope Works, Ltd., Brykil Street, Wolverhampton	**Reliance, Wolverhampton.**
Lancaster & Tonge, Ltd., Pendleton, Manchester	**Pistons, Manchester.**
Lincolne & Co., 65 and 67 North Wallace Street, Glasgow	Lincolne, Glasgow.
Loco Packing Co., Boreham Wood Works, Elstree	Packing, Elstree Station.
The Frictionless Engine Packing Co., Cable Mill, Oldham Road, Manchester	**Packless, Manchester.**
United States Metallic Packing Co., Bradford	**Metallic, Bradford.**

STEAM TRAPS.—Boites à Vapeur.—Condensationstopfe.—Valvalas de Retencion de Vapor.

Holden & Brooke, Ltd., Sirius Works, West Gorton, Manchester	Influx, Manchester.
Lancaster & Tonge, Ltd., Pendleton, Manchester	**Pistons, Manchester.**

STONE BREAKERS.—Broyeurs de pierres.—Steinbrecher.—Quebrador piedras.

Baxter, W. H., Ltd., Gelderd Road, Leeds	**Knapping, Leeds.**
Mason Bros., Brandon Street, Leicester	Breaker, Leicester.

WELL BORING TOOLS.—Outils pour le sondage de puits.—Brunnen-Bohr Werkzeug.—Herramientas para abrir Pozo.

Isler, C. & Co., Bear Lane, Southwark, S.E.	**Isler, London.**

WOODWORKING MACHINERY.—Machines pour travailler le bois.—Holzwerkzeug Maschinen.—Maquinaria para trabajar la Madera.

Bale, M. P. & Co., Appold Street, Finsbury, E.C.	
Bolinders, J. & C. G., Ltd., Stockholm	
Campbell, W. H. & Co., 25 Boundary Road, Middlesbrough	Campbell, Middlesbrough.
Grantham Crank & Iron Co., Ltd., Grantham	Land, Grantham.
Green & Nephew, J., Cudbear Street, Leeds	Green, Nephew, Leeds.
Kirchner & Co., Ltd., 118 Queen Victoria Street, London, E.C.	Kirchner, London.
Lees, T. & R., Hollinwood, nr. Oldham	**Lees, Hollinwood.**
Pollock, McNab & Highgate, Fir Park Iron Works, Shettleston, Glasgow	Highgate, Shettleston, Glasgow.
Ransome & Co., Ltd., Stanley Works, Chelsea, London, S.W.	
Ryland & Bird, Brixton, London, S.W.	
Sagar & Co., J., Canal Works, Halifax	Sagars, Engineers, Halifax.
Yates & Co., A., Luddenden, *viâ* Manchester	


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The Engineering Times.

VOL. I. APRIL-MAY 1899. No. V

ENGINEERING TOPICS.

English Orders Placed Abroad!!!

There has been a great deal of talk about orders for locomotives and bridges going to America. The whole thing has been greatly exaggerated. We do not propose to deny that a certain bridge order has been placed by one of our Government departments with an American firm, nor that the Midland and Great Northern Railways have done the same in respect to certain locomotives. But has it ever struck our readers that Pullman cars, and a number of other things we might mention, have been coming over here for years past, and without doing us any harm, nor creating the outcry now so prevalent. Let us, however, look the facts fairly in the face. In the first place, the main reason assigned for our makers not booking these orders was that they were unable to execute them in the time asked for, because they were so busily engaged night and day on other work, and we may well assume on exceedingly profitable work, if the present rate of prices is any indication. Now, if any other reason than this were the cause, such as our prices being too high, for instance, we might well deplore the condition of things, but when we remember that these orders could practically have been secured by our firms, in fact were offered to them, this does not appear to us to be sufficient ground for the extraordinary views which some of our contemporaries have seen fit to ventilate.

It must always be borne in mind that outside the railway companies themselves, there are, comparatively speaking, a limited number of firms who lay themselves out for building heavy locomotives, and these particular firms are now exceedingly busy. If this extraordinary demand for locomotives and Atbara bridges were likely to continue, it would doubtless pay to establish a big locomotive industry outside our loco shops, but such extension cannot be carried out at a moment's notice, or at any rate quick enough to give prompt delivery. Moreover, if our home railway companies can as a rule meet their own requirements our principal market would be to our colonies, and such continental firms as do not build for themselves. These are getting fewer year by year, and whatever hopes we may have had in that direction some of our theoretical George Street engineers have assisted to crush them by insisting on such severe conditions as to frighten our manufacturers. But, after all, is there call for all this agitation? We cannot lose sight of the fact that America is not only a

larger country than this, but possesses both a greater railway mileage besides more locomotives, and has also encouraged private locomotive building, and at a time of great pressure on this side is able to supply in shorter time than we care to, but that such a fuss should be made about a few orders for locomotives, and a bridge for the Soudan going abroad is too absurd!

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Much ado about—little.

When we see it stated that "American ingenuity, enterprise and pluck, have over and over proved themselves capable of downing the foreigner in his own market," we say that such stuff is arrant nonsense, and however much our friends across the Atlantic may wish this were the case, their desire has not yet brought it about. The world acknowledges and admires the ingenuity and cast-iron enthusiasm of our American friends, but when they rave and gloat over the reception of a few orders which —for what reasons it matters little— our firms did not see fit to appropriate, the situation becomes burlesque. All this hubbub reminds us of the following which once appeared in a Cincinnati paper :—

"This is a glorious country! It has longer rivers and more of them, and they are muddier and deeper, and run faster, and rise higher and fall lower, and do more damage than anybody else's rivers. It has more lakes, and they are bigger and deeper, and clearer and wetter, than those of any other country. Our rail-cars are bigger, and run faster, and pitch off the track oftener, and kill more people than all other rail-cars in this and every other country. Our steamboats carry bigger loads, are longer and broader, burst their boilers oftener, and send up their passengers higher; and the captains swear harder than steamboat captains in any other country. Our men are bigger, and longer, and thicker; can fight harder and faster, drink more mean whisky, chew more bad tobacco, and spit more and spit further than in any other country. Our ladies are richer, prettier, spend more money, break more hearts, wear bigger hoops, shorter dresses, and kick up the devil generally to a greater extent than all other ladies in all other countries. Our children squall louder, grow faster, get too expansive for their pantaloons, and become twenty years old sooner by some months than any other children of any other country on the earth."

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Lord Charles Beresford as a "Commercial Traveller."

Such was the title that Lord Charles Beresford was pleased to confer upon himself in connection with his recent journey to China when making what was the speech of the evening at the Annual Dinner of the Institution of Mechanical Engineers. But it was more than evident from the subsequent remarks which fell from the lips of our popular naval Lord that interests other than strictly commercial ones had been engaging his attention during his journeying in foreign parts. He had noticed, amongst other things, that foreign navies were applying electrical energy in the controlling and driving of the intricate machinery with which our modern warship is now fitted, to an extent not attempted by our engineers, and with results exceedingly satisfactory, especially in reference to ventilation.

However unpalatable such information may be to our engineers, it is to the credit of his Lordship that he

has the courage of his opinion and is not afraid to express them to such a representative body as the Institution of Mechanical Engineers. This country cannot afford to draw too deeply upon the credit of its past achievements, and such outspoken language is the surest safeguard for our future welfare. The high tribute paid to the professor of mechanical engineering both by Sir Henry Brockenbury in his capacity of Inspector General of Ordnance, and the Right Hon. G. J. Goschen, M.P., as First Lord of the Admiralty, go to indicate the increasingly important position now occupied by engineers in relation to our Army and Navy.

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Trade with Russia: Important Statement.

SIR HOWARD VINCENT'S persistent questioning in the House has, at last, elicited from the Government some definite information regarding our trade relations with Russia. The subject is one of immense importance —for there is no room to doubt that in view of the concessions made, and about to be made, by Russia, in the matter of import duties on machinery, the Czar's dominions will become one of the most inviting foreign markets to British manufacturers. Sir Howard recently asked what arrangements Lord Salisbury proposed to make to second the efforts of the Finance Minister of H.I.M. the Czar to develop British trade in Russia, to which Mr. Brodrick replied that it was the intention of the Government shortly to take further steps in certain districts to develop British trade; and the opportunity for encouraging our trade in Russia would be carefully considered.

This is exceedingly gratifying to us, for apart from the benefit which must accrue to British trade, we can modestly claim to have been to some extent instrumental in bringing about this encouraging state of affairs. In a recent issue we published an interview which the writer had with Count Tatistcheff of the Russian Imperial Ministry of Finance—and which was widely quoted in the daily and technical press — which has doubtless cleared the public mind to a very

CHARLES BRIGHT, F.R.S.E.
Writer of "Coast Electrical Communication" herein.

large extent regarding the attitude of Russia towards British trade and traders. As Count Tatistcheff then stated, British traders have the idea that in Russia they will not be treated fairly. It is an utter mistake, for not only will they receive proper treatment, but our authorities will extend to them all the assistance they possibly can. English traders are welcomed in every part of Russia, and more so than those of any other country.

What To Do With Our Refuse.

Whilst the problem has been solved, and in the most simple way, viz., by burning, the difficulty still remains in getting local authorities to apply the system. We do not realise the immense amount of energy which is waiting to be extracted from what we are pleased to term waste products or refuse; and what is at present not only a great inconvenience, but a possible harm, may easily be converted into something useful and beneficial. We also know that nothing can be destroyed, that all we can do is simply to change the form of things. Moreover, that all kinds of force are convertible, and the transformation of town refuse into electric light is a most desirable conversion, besides being a paying one, when properly worked. There are a number of destructors or furnaces on the market at the present time, all claiming to be the best, and naturally covered by patents; but where the patent "comes in" in the majority of them it is difficult to understand. Of course, the method of converting refuse into electric light is simply to use refuse in place of coal for the boiler which generates steam to drive the electrical plant. This seems simple enough at first sight, and with the system of forced draught now adopted this is really so, but first attempts produced so much dust and fumes from the chimney stack that much trouble was caused. One of the most important features in a dust destructor plant is the forced draught. Certain makers claim for steam jets the best results, and others, that an air blast produced by fans is superior.

As to the efficiency of refuse destructors, it may be taken that almost any of them can evaporate ¾lb. to 1lb. of water per lb. of refuse burnt, and 1½lb. of water per lb. of fuel is likely to be obtained if it has not already been done, but taking the lower figure, how does this work out as against coal? A fairly economical boiler will evaporate, say 8lb. to 10lb. of water from feed water at 100 deg. F., and after making all allowances it will be noticed that at least five or six times as much refuse is required to raise the same amount of steam But then we must remember that the refuse costs practically nothing beyond handling, and this has to be done whether it is burnt or not.

We are preparing an exhaustive series of articles on this important subject, the first of which will appear in an early issue.

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Automatic Couplings.

Considerable attention has been devoted of late to the important question of automatic couplings as applied to rolling stock. Even supposing the Government does not see its way to legislate on the matter for the moment, there is very little doubt that an automatic system is bound to come sooner or later; in fact, it is here already to a limited extent, as at the present time there are something like 300 vehicles in England fitted with an approved foreign coupler which has already done good service. The report of a number of prominent railway officials and others who have now returned from America, would go to show that, apart from the saving of life and limb, the saving to the railway companies and others has been very considerable. Private wagon owners in the States at first raised objections to the system on account of initial cost, but after a short time of working they admitted that the couplings soon paid for

themselves in the saving of the costs of repairs alone.

As to first cost, the statement made by wagon owners and colliery proprietors on this side, that this would be something like £10 per wagon is excessive, as £3 is ample to cover the price of a satisfactory coupling, and this amount might possibly be reduced if new stock was fitted right away. In view of the great improvements that have been made to our rolling stock during the last few years, it is difficult to understand why this much needed reform is so slow in coming about, but it is significant that 80 per cent. of the railway stock in the United States is fitted with some sort of automatic coupler, and that on January 1st of next year a law will come into operation, making their universal application imperative.

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The Metric System.

We had occasion in our last number to briefly indicate approval of this system, but more particularly to show that any immediate or cumpulsorily universal adoption of it was fraught with some degree of danger and inconvenience.

As is well known, the principle of the metric system lies in the use of one fundamental unit for measures of length, capacity and weight, and, so far as its simplicity and adaptability to everyday requirements are concerned, no one who has ever studied the subject would question its value. Why do we in this country divide a gross into 144 parts, a ton into 2,240 lb., a rod into 5½ yds., or a mile into 5,280ft., whilst a nautical mile equals 6,080ft.? Again, why do we have two measures of weight, in the one dividing 1 lb. into 16 oz., and the other into 12 oz.? These and other questions might well be asked, but it is very difficult to find satisfactory answers. Our system doubtless served its purpose when it was originated, and has done so with more or less success for many years, but we venture to think that the time has now arrived for us to adopt the metric system. There is no doubt that our refusal to meet the convenience of our foreign clients in this connection—especially in places where our system of weights and measurements is almost entirely unknown—is one of the reasons why German and other Continental firms are getting hold of some of our business. The fact that Continental makers and merchants use the metric system would not alone be sufficient to justify our making the change; but when it is remembered that the system is immensely superior to ours, saving a large amount of time, not only at the works, but also in the counting house, it is difficult to understand why we do not at least adopt it in our foreign transactions. This would not involve any great or sudden change, and, whatever inconvenience or expense it might entail, the advantages accruing from it would be found to outweigh the cost. Such, indeed, is the experience of several up-to-date English firms who have adopted it with much advantage to themselves and their clients.

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Machine Tool Lecture at the Royal United Service Institution.

An interesting paper entitled "Machine Tools" was recently read by one of our contributors, Mr. E. C. Amos, M. I. Mech. E., before the Society of Engineers at the Royal United Service Institution, Whitehall, and has created considerable attention. A large portion of the paper was devoted to this country's position in relation to its foreign competitors,

and especially America, and produced a valuable discussion, in which expression was given by a representative technical audience to many of the views advanced by our contributor in these pages. The paper was illustrated by over 50 half-tone blocks, some of which had already appeared in this journal; the majority, however, were specially made for the paper which was a very creditable production. The difficulty, as expressed by some of the audience, of getting English tools is just now fairly widespread, and there is no doubt that buyers are better able to get reasonable delivery of tools by obtaining them from America. The immense demand for tools at the present time has not only made our makers exceedingly busy, but judging from what we hear on all sides has produced a want of enterprise and forethought for the future—we regret to have to admit it—which is much at variance with the customary cautiousness of Englishmen.

Only a few days ago we learned from a resident in India, and who is well acquainted with that country, that he advertised for agencies which he proposed to take up. His replies, thirteen in number, included letters from seven German houses, two American, and only four English, although the advertisement appeared in an English paper. Even supposing that this country is well represented in India—a supposition open to question—it still indicates the amount of enterprise which our keenest competitors are exhibiting in the extension of their foreign business.

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Electric Traction.

In 1890 there were 2,525 miles of electrically operated track in the United States, and 5,592 cars with a capital of something like £7,000,000. In 1895 this had increased to 10,752 miles and 35,000 cars, and at the present time there are probably 20,000 miles and some 60,000 to 70,000 cars if not more. In this country, in 1896, there were some 200 miles of track with 300 cars, and even if we quadruple this for the increase during the last three years, and that is probably excessive, we see at once that there is a big difference. We must not forget, of course, that we have a large mileage of horse trams besides steam and cable tramways, and this country is well studded with heavy main lines, but there is a great need for light railways in country districts as well as near large towns.

As to working expenses, these are distinctly in favour of the electric system, as in this system the ratio of operating expenses to receipt averages is well under 60 per cent., whilst in English horse tramways it is not infrequently as much as 75 to 80 per cent. On the Continent we find that Germany is considerably ahead of us in electric traction, and is rapidly increasing her lines, and we are glad to see that we are also going ahead in this direction. The growth and development of electric traction is a subject in which considerable interest is now being evinced.

HIGH-SPEED STEAM ENGINES.

By W. NORRIS, A.M.I.C.E., M. I. Mech. E.

V.—SOME AMERICAN TYPES DISCUSSED.

THE engines described in the previous articles on high-speed steam engines have been those manufactured by English firms. Whilst on a business trip to the United States of America the writer had considerable opportunity of watching the behaviour of several types of high-speed engines built by the leading makers in the United States of America.

A type of engine which has been highly successful is that known as the Russell Engine, built by Russell and Co., Massillon, Ohio.

Fig. 28 is a front view of the simple type of Russell Engine. The bed is of the "box" type, or a combination of the well-known "Tangye" and "semi-girder" patterns, with projecting cylinder, free to expand whilst working. The guides are bored, and permit a certain amount of self-adjustment in the crosshead.

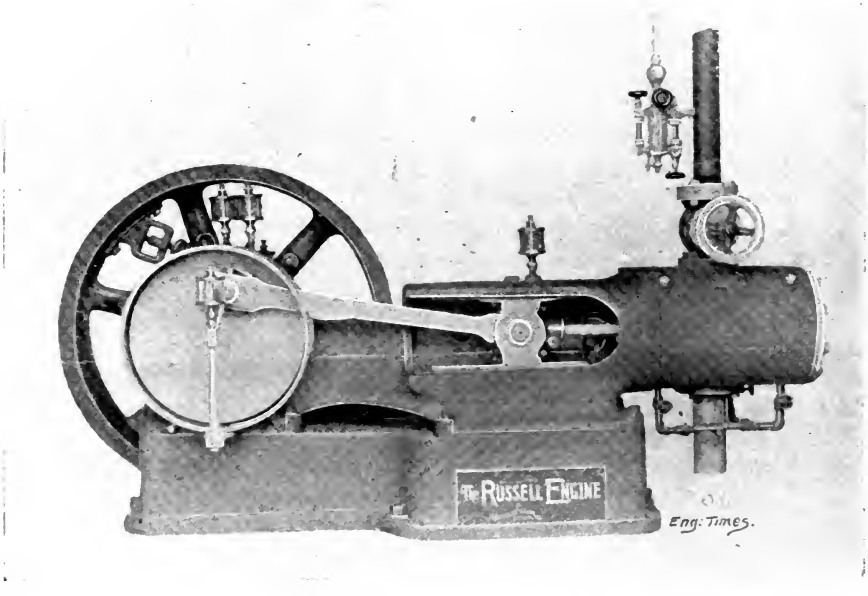


FIG. 28.—FRONT VIEW OF RUSSELL ENGINE.

Fig. 29 is a part sectional plan through the cylinder and steam chest. It will be seen by reference to Fig. 29 that the admission valve is double ported and balanced through needle ports leading into steam and exhaust ports. The steam chest cover is surrounded with a light casing, which not

only gives a neat appearance to the steam chest, but admits of ready removal in case of overhaul.

The proportions of the main shaft and crank pit are somewhat different to English practice. The main bearing is $\frac{1}{2}$ the crank pit, $\frac{1}{4}$ the diameter

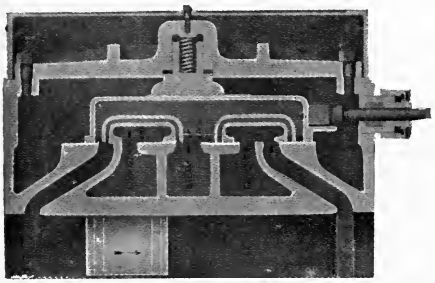
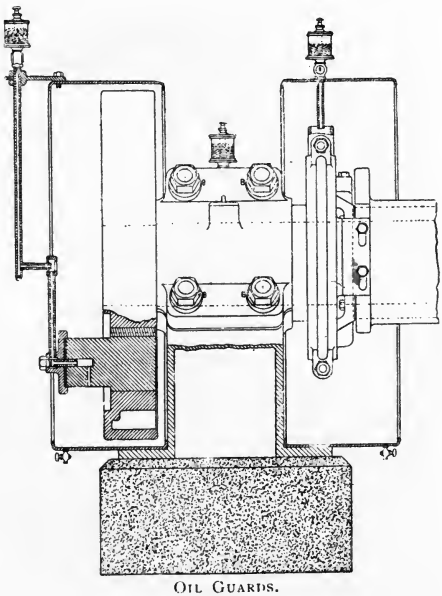


FIG. 29.—RUSSELL ENGINE—PART SECTIONAL PLAN THROUGH CYLINDER AND STEAM CHEST.

of the cylinder. The arrangement of oil guards will be clearly seen by reference to Fig. 30.

The governor (see Fig. 31) controls the speed of the engine through the inner eccentric R, which fits loosely on the hub of the governor wheel A, and is connected with the weight arms F, through the links K, in such a manner that the inner eccentric is moved round the hub of the governor, forward or backward, as the weights change their position. This forward or backward movement is communicated through the inner eccentric strap Q to the main eccentric B, causing this to slide on the hub plate C, in a *straight line across the shaft*, thus maintaining a constant "lead" for all points of cut off. This movement across the shaft is always in the direction of reducing the eccentricity of the main eccentric, consequently reducing the travel of the valve.

When the weights are at the inner position, the throw of the eccentric is at its maximum, and steam is admitted $\frac{3}{4}$ of the engine's stroke. When the weights are at their extreme outer position the throw of the eccentric is at its minimum, and the steam is cut off at the beginning of the stroke. Between these two extremes any number of positions of the weights and corresponding angular positions of the eccentric may be had, and as the steam is thus adapted to the load in each position, it follows that a slight increase or decrease in speed must make a change in the cut-off, and to bring the engine again to standard speed. The free movements of the weights F, is opposed by the springs H. By tightening the tension screw N, the force of the springs is increased, and by adding weights to the weight arms F, the centrifugal force for any given speed is also increased. Now it is clear that there is a point where these two forces exactly balance each other, and but for the



OIL GUARDS.

FIG. 30.—RUSSELL ENGINE—SHOWING ARRANGEMENT OF OIL GUARDS.

unsteadiness produced by the equilibrium of these two forces, this would be the proper adjustment for the best regulation. It is Messrs. Russell's practice to give a small preponderance to the weights F, by reducing the tension of the springs just enough to overcome the unsteadiness, and after the spring tension has been thus adjusted, it should not be tampered with to make any desired change in speed as speed should always be adjusted at the weights and not at the springs.

Fig. 32 shows very clearly Rite's governor, which is now fitted to the Russell engine.

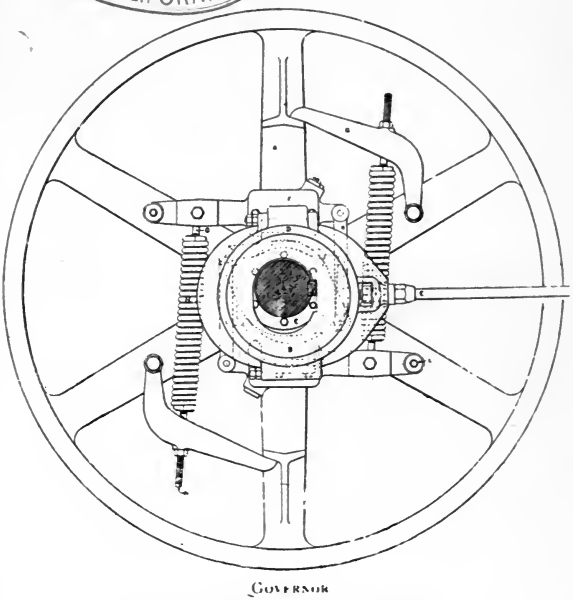


FIG. 31.—RUSSELL ENGINE—GOVERNOR.

The single cylinder engines are made in sizes from 18 h.-p., cylinder 6in. bore × 10in. stroke, making 325 revolutions per minute, up to 175 h.-p., with cylinder 16in. bore × 20in. stroke, making 175 revolutions per minute. Steam pressure 125 lb. per square inch.

A very neat type of tandem compound engine is made by Messrs. Russell and Co., which is largely used for driving dynamos direct. See Fig. 33.

It is well known that the greatest economy attached to the use of the compound engine is obtained when running it condensing, as the larger area of the low pressure piston exposed to the action of a more or less perfect vacuum, adds considerably to the efficiency of the engine. The ratio between the cylinders should be greater for condensing than for non-condensing engines

FIG. 32.—RUSSELL ENGINE—RITE'S GOVERNOR.

to obtain the best results, but as already mentioned (see THE ENGINEERING TIMES, p. 96) engines fitted with a condenser, often are compelled to be run non-condensing for a longer or shorter period of time, owing to lack of sufficient water supply or other causes, and as engines originally intended to be run non-condensing are later supplied with a condenser, Messrs. Russell proportion the cylinders of their engines so as best to meet both these extremes, so that whilst recommending the use

Referring to Fig. 33, this type of High-speed Tandem Compound Engine possesses several very good features, and is admirably suited for driving dynamos direct. It will be seen that the engine and dynamo are arranged on one base. The receiver between the high and low pressure cylinders forms a substantial support for both cylinders, and is well arranged for sliding the cylinders. Every part of the engine is get-at-able, and is altogether a first-class job. The tandem engines are made in sizes

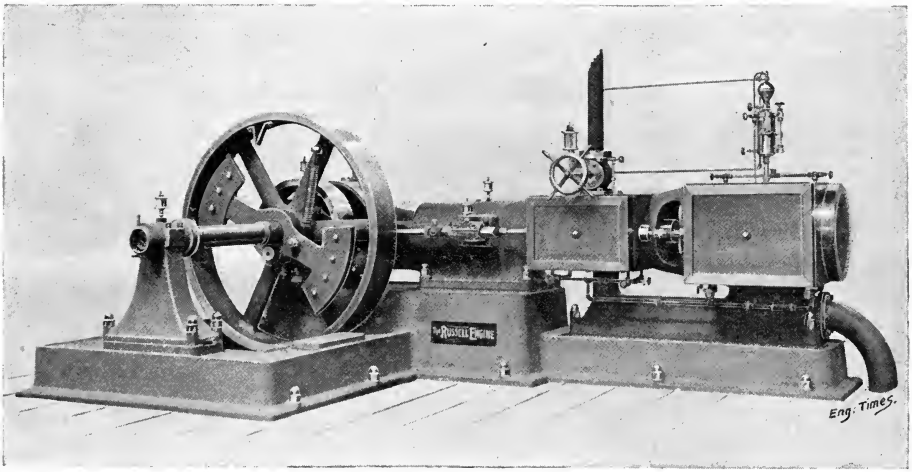


FIG. 33.—THE RUSSELL HIGH-SPEED TANDEM COMPOUND ENGINE.

of a condenser in connection with their compound engines, they claim that with a high steam pressure of, say 125lb. per square inch, almost as economical results can be obtained non-condensing as condensing. The writer is very much inclined to agree with Messrs. Russell on this point, having for some considerable time failed to see how a condensing plant for a small installation of, say, 100 h.-p, would warrant the outlay, to say nothing of the up-keep.

from a 9in. × 14in. × 14in. stroke, making 260 revolutions per minute, up to 13in. × 20½in. × 20in. stroke, making 210 revolutions per minute. The cut-off, non-condensing = ·30, and condensing, ·20 of the engine stroke.

A representative type of American high-speed single-acting engine is that so well known as the "Sentinel" Westinghouse, as made by Messrs. Alley and Maclellan, Glasgow. About twelve years ago Messrs. Alley and Maclellan started the manufacture of the simple type of

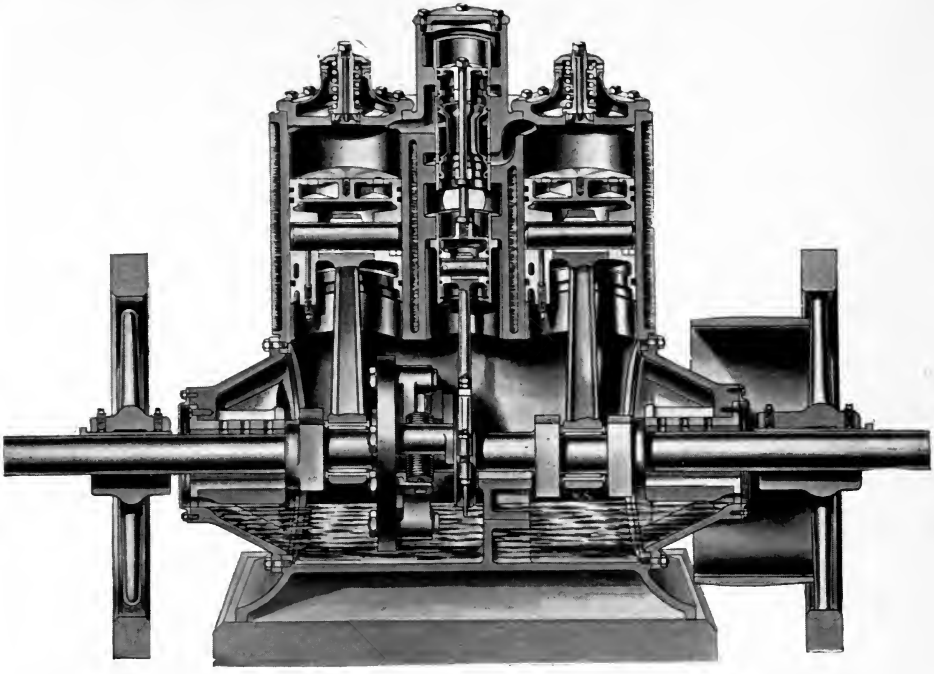


FIG. 34.—LONGITUDINAL SECTION THROUGH CRANK SHAFT—"SENTINEL" SIMPLEX HIGH-SPEED ENGINE.

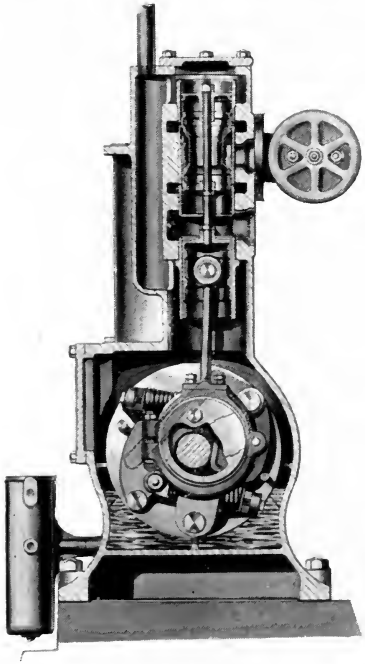


FIG. 35.—TRANSVERSE SECTION THROUGH VALVE.—"SENTINEL" SIMPLEX ENGINE.

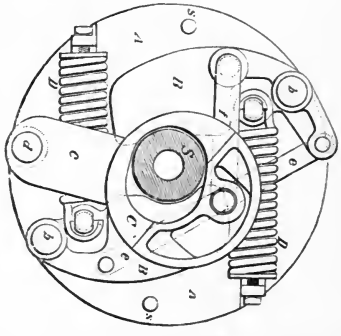


FIG. 36.—GOVERNOR—"SENTINEL" HIGH-SPEED ENGINE.

Westinghouse engine, and have during that period had a very large experience. There are now some 7,000 engines of this type in operation all over the world. The simple engine is of the two-cylinder, two-crank type, having the cranks set at 180 degrees and is made in sizes up to 350 i.h.-p., and is specially adapted for running non-condensing. Fig. 34 is a longi-

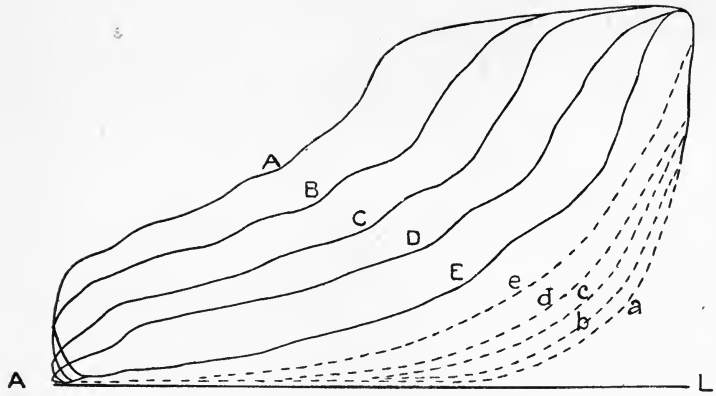


FIG. 37.—INDICATOR DIAGRAMS—"SENTINEL" HIGH-SPEED SIMPLEX ENGINES.

tudinal section through crank shaft, and Fig. 35 is a transverse section through valve. It will be seen by referring to Figs. 34 and 35 that all the moving parts, with the exception of the fly and belt wheels, are enclosed within the frame of the engine, and on further examination it will be noticed that the internal moving parts consist of two pistons, two connecting rods, crank shaft, a single central valve, eccentric rod for same and an automatic expansion governor. Not a single gland or stuffing box is required in the whole engine. The pistons are of the trunk pattern, and of great length, which ensure a long life. It is well known that the pistons of the "Otto" type gas engines, which are of the trunk pattern, fitted with rings only at the back end, give excellent results, and though the conditions such as varying temperature are very severe, yet the mechanical efficiency is

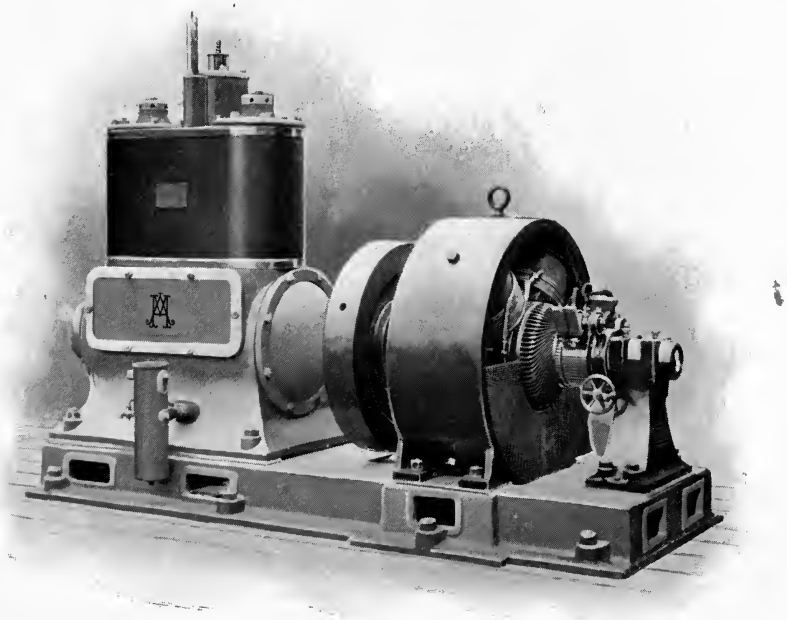


FIG. 38.—"SENTINEL" HIGH-SPEED SIMPLEX ENGINE COUPLED DIRECT TO DYNAMO.

remarkably high. Bearing this fact in mind, then nothing can be urged against a well-designed plunger piston for single-acting engines. The steam is distributed to the two cylinders by a single balanced piston valve, and acts only on the top of the pistons, making the engine single acting throughout the whole revolution, the inertia of the reciprocating parts being taken up by judicious compression of the exhaust steam on the return or up stroke.

The governor is of the crank shaft variable expansion type, and acting direct on the travel of the balanced piston valve, as shown in Fig. 35, controls the supply of steam at four points in each revolution. This governor is shown in Fig. 36, and its action in controlling the steam at varying loads is shown in Fig. 37.

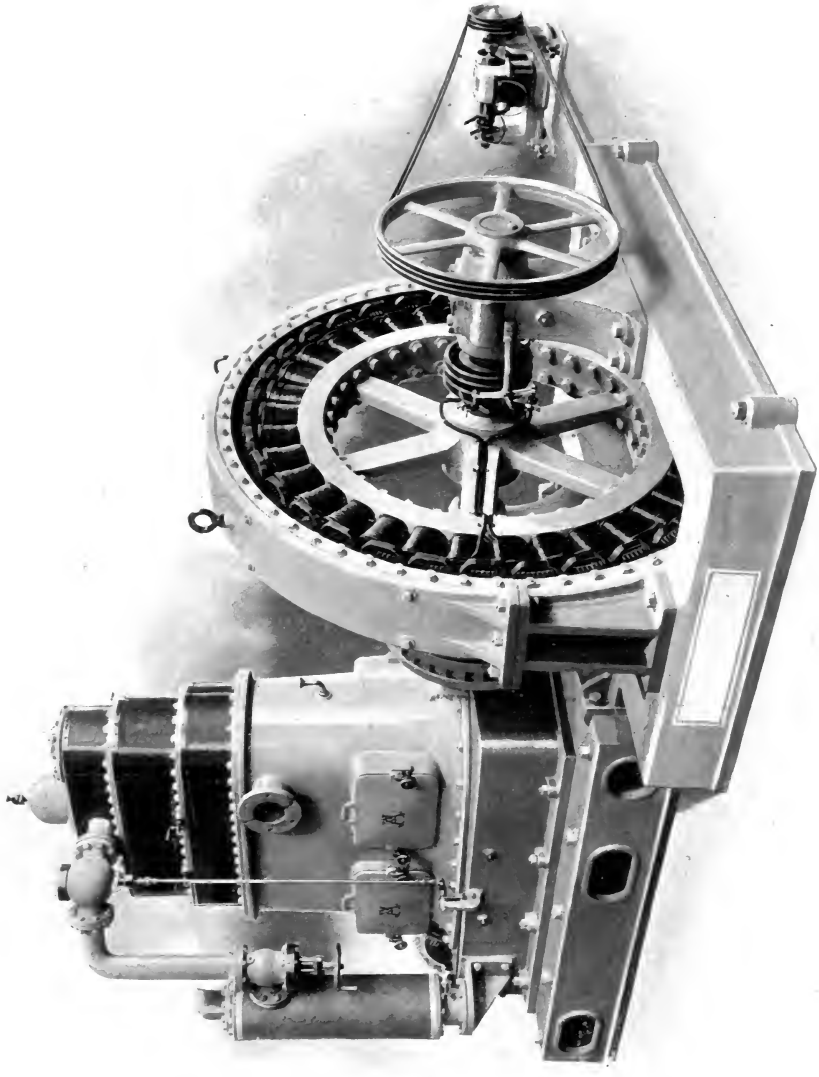


FIG. 39.—"SENTINEL" HIGH-SPEED TANDEM COMPOUND ENGINE COUPLED DIRECT TO ALTERNATOR.

All the internal packings are of the floating metallic type. Large bearing surfaces are provided, so that the wear is reduced to a minimum, the bearings varying in length from 2 to $3\frac{1}{2}$ times the diameter of the shaft. The main bearings are not provided with any means of adjustment. Shells lined with Babbit metal are provided which admit of easy renewal.

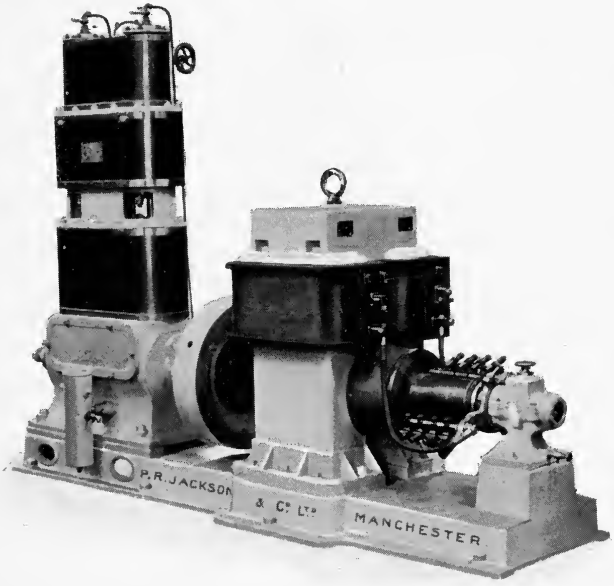


FIG. 40.—"SENTINEL" HIGH SPEED TANDEM COMPOUND ENGINE, COUPLED DIRECT TO DYNAMO.

Lubrication is effected in both simple and compound types by having the crank case half filled with oil and water or all oil nearly up to the height of the crank shaft; this, when the engine is running, is in a few minutes churned into a foam, which, while it offers little or no resistance to the moving parts, thoroughly lubricates all internal bearings constantly, and, by using the same oil over and over again, economically.

Governing is effected in the compound engines either by a variable expansion governor, as in the simple engine, or by a shaft governor operating a throttle valve and capable of adjustment while running, and such is the sensitiveness that these engines are made to govern within 1 per cent. between no load and full load.

Fig. 38 shows one of these simple engines of 50 b.h.-p. direct driving a dynamo at 430 revolutions per minute.

The compound engine, as now made by Alley and Maclellan, is chiefly of the tandem type, and, like the simple engine, is also single acting. It is made with two cranks generally, but when exceptionally steady running is desired it is made with three cranks set at 120, the two-crank engine having its cranks at 180.

Fig. 40 shows one of these engines of 20 b.h.-p. direct driving a dynamo at a speed of 500 revolutions, and Fig. 39 shows one of 250 b.h.-p. driving an alternating current generator at 350 revolutions as supplied for central electricity supplied stations.

Distribution of steam is effected by simple piston valves and is on the Cornish cycle, the steam acting on the top of the horse-power piston, then exhausting to the under side of this piston, which forms a receiver into the low pressure piston, then again exhausting to the bottom side of this piston, and finally exhausting to the atmosphere or condenser as the case may be.

(To be concluded in next issue).

W. Morris

COAST ELECTRICAL COMMUNICATION.

By CHARLES BRIGHT, F.R.S.E., A.M. Inst. C.E.

WHAT is meant by coast communication, is the connection by telegraph of the mainland, islands, rock lighthouses, and lightships. The points of connection on the coast, should, of necessity, be as near as practicable to coastguard and life-boat stations, those stations being in continuous telephonic communication with one another, and with the nearest postal telegraph offices. By this means we should have a rapid transmission of information along our shores, the value of which could not be over-estimated, whether in time of peace or war. In peace, these lines of communication would be of inestimable use in saving hundreds of valuable lives; in war, they might be the means of saving the nation.

That part of the subject which is now occupying a considerable amount of public attention is the matter of the establishment of telegraphic communication between rock lighthouses and the adjacent mainland. It is obviously a work for which it would be advisable and, indeed, almost necessary to obtain the assistance of engineers who have had experience in matters connected with the construction of lighthouses, and it is to be hoped that these will give their advice to the benefit of a scheme which has to a great extent humanitarian objects in view.

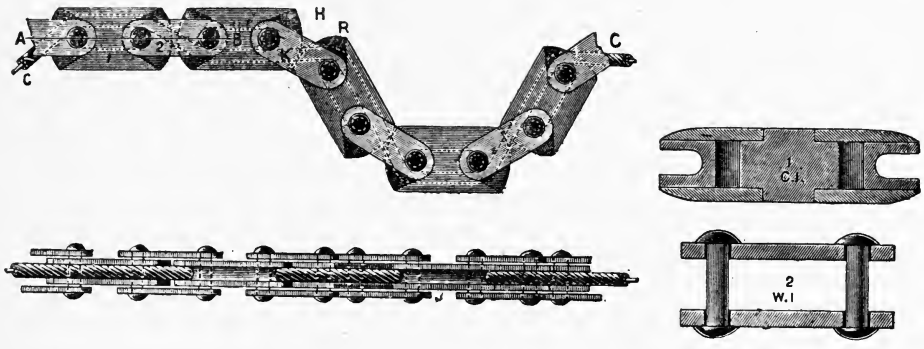
The work of laying submarine cables is one which, in the ordinary way, presents no very great difficulties, and which is now carried out with great efficiency; but there are few engineers engaged in this who would not be glad of assistance in such a case as the laying of a telegraph cable to, let us say, the Bishop's Rock Lighthouse.

It must be pretty apparent to anyone that an ordinary type of cable, laid in the usual way, would stand no chance when exposed to such severe conditions as, in this instance, it must necessarily be. Such a cable was laid to the Fastnet Rock a few years ago, but it only lasted a short time, and the attempt has, perhaps, done harm by establishing a popular idea that the carrying out of the scheme presents serious difficulties from a technical point of view.

Engineers who have so successfully overcome the great difficulties encountered in the construction of these very lighthouses with which it is now proposed to establish communication, will, surely, not think that the carrying out of this scheme presents any but comparatively trivial difficulties, to overcome which no exorbitant expenditure of money is necessary.

The method of carrying out the work must necessarily vary considerably with the different condition pre-

sented by different rocks; but in every case there can be little doubt that the telegraph cable must be secured to the rock and embedded in it to a distance of about five fathoms below low water mark, in order to protect it from the force of the sea. In the case of the Bishop's Rock Lighthouse, there is no reason why an ordinary type of cable, secured in this way, should not prove perfectly durable; but there are other instances where the inclines of the rocks are not so precipitous, and where no deep water—and consequent security—is to be found. In these cases the ordinary type of cable should be embedded in the rock to the bottom of the first precipitous incline, from which point a specially designed cable should be employed, protected by a form of chain armour recently invented by Mr. Edward Stallibrass, A.M.Inst.C.E., which is shown in the accompanying sketch.



C, CABLE; C I., CAST IRON; W I., WROUGHT IRON. SECTION OF LINKS AT A B.

The ordinary types of submarine cables are quite unsuited to an irregular rocky bottom with shallow water, and consequently strong tidal currents, or—it may be—even breaking seas. The reason of this unsuitability is as follows :—

(1) The extreme inflexibility of such cables, rendering it absolutely impossible for them to fit closely down to the bottom, and make use of any irregularities as actual protection; therefore, we have lengths of cable laying in spirals along the bottom or hanging across from ledge to ledge of rock, and unnecessarily exposed, with the result that the cable soon becomes worn through at the nearest point of suspension.

(2) The small weight of these cables in water, as compared with the surface exposed, rendering them liable to be washed about on the bottom: the specific gravity of an ordinary cable used on rough bottoms is about 4.

In the chain armour above referred to (see illustration) great flexibility is secured by employing a small type of cable, made in itself as flexible as possible, and protecting it with a heavy but flexible chain. The chain is composed of castings fastened together with wrought iron, and so constructed that the cable, when threaded through its links, is afforded absolute

protection; while the flexibility of the chain will admit of it being zig-zagged about among the irregularities of the bottom, thus converting these from a source of danger into an absolute protection.

On a bottom free from irregularities the great weight of the chain would prevent any serious movement.

The cost of the chain would be heavy per mile; but as its use would only be necessary for very short lengths—at exposed positions and on rocks—this consitutes no grave objection.

Divers should be employed to see that the cable is properly laid; and, this once being done, such a cable might confidently be expected to last a reasonable time.

MACHINE TOOLS.

By EWART C. AMOS, M. I. Mech. E.

V.—FURTHER CONSIDERATION OF AMERICAN COMPETITION.

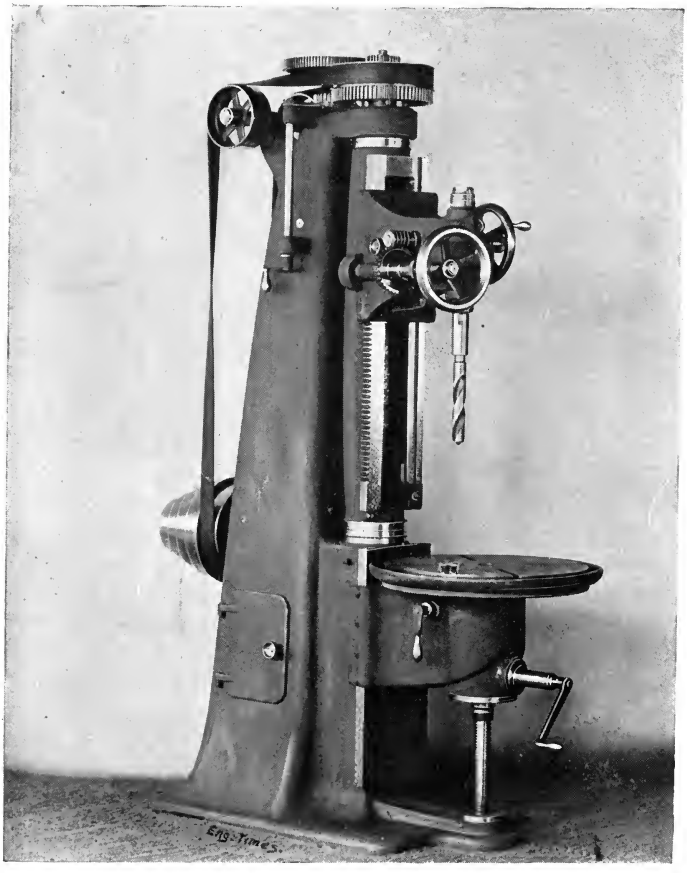
WHEN dealing with the question of British *v.* American tools in these articles, the author has largely confined himself to a comparison of the machines themselves, rather than to a consideration of the reasons that have made it possible for the American machines to so readily find a market here. It may safely be stated that they have now got a strong foothold in this country, and it may perhaps also be found interesting to briefly consider how this has come about. In the first place, we should not be buying American tools to the extent we are if we did not find them serviceable. The statement—more often the excuse—so frequently made that we only buy American machines because we cannot get British will not bear repeating any longer; anyone who is conversant with the market at the present moment knows this, and those who dispute it do so from a want of knowledge of the facts of the case. Undoubtedly there have been many instances when it has been impossible to get an English machine in the time required, and resort has been had to an American tool simply because it has been in stock, but that alone will not explain the increasing demand for the imported article. Now let us look into the question of cost, which is a very important side of the question. It is generally recognised that the true worth of a tool is to be measured not so much by its prime cost, as by the amount of good and accurate work it will produce in a given time, and the correctness of this method of valuation becomes the more apparent as the rate of wages continues to increase. Automatic tools have become the order of the day; since although their initial cost is high, their productive capacity bears a corresponding ratio. It is generally supposed that labour in America commands a high wage. This is perfectly true up to a point, but supposing that the American workman, in conjunction with American workshop practice and American machines can turn out a corresponding increase of work, we find here the explanation of how it is that American tools plus freight and showroom expenses on this side, can still be sold at prices comparing very favourably with our machines of a similar quality. These are facts which it would be unwise to ignore, but still more unwise to simply admit without enquiring more closely into the far-reaching causes which produce them. American engineers have found that if they, with a high wage rate, are to compete with other countries paying a less wage, they must dispense with manual labour as much as possible, and their practice is briefly this,—to construct machines so automatic in their nature that it has become possible to employ practically unskilled labour to a large extent, engaging at the same time

highly-skilled and thoroughly educated foremen and managers to superintend the setting and keeping in order of the automatic machines which can then be left in the hands of unskilled men, who can only command a low wage. Then, again, it must be remembered that the American mechanic is a different class of man to what we have over here, and he is so because he receives a better and more advanced technical training and also works under more congenial conditions, occupying at the same time a superior social position. The same shop can be made to turn out more or less according to the practices adopted and this leads up to the question of specialisation. Our tool-makers are generally too apt to manufacture a great variety of machinery, which calls for a big pattern department, and they would probably do better were they to follow the American and German practice of making a number of similar machines at the same time, which enables additional labour-saving appliances in the form of jigs, templates, etc., to be profitably employed. In the author's opinion the time is rapidly approaching when electricity will play a far more important part in the driving of machinery and especially machine tools than it does at present; belting and overhead gears will be replaced by electric motors and speed reducing gears, with automatic arrangements for taking on the full load, without damage to the motor. America has already gone in for this extensively, and this country will do well to direct its attention to a similar method of driving. Looking across a large shop, one is struck with the immense amount of belting, pulleys, shafting, bearings, etc., which are now used, but which might be dispensed with if electric driving were adoped. The question of space alone, apart from danger to the operators, is an important item. Compressed air will also play a very important part in the near future, as it lends itself so advantageously to the driving of tools, which can be used in place of hand tools. As to the commercial side of the question, there is no doubt that our foreign competitors have fully proved the great value of exhibiting their machines, and by means of well-got-up catalogues and a prompt and careful attention to their clients' wants, have secured a footing which it will be difficult to remove.

As a set off against this foreign inroad into our markets, what do we find? In the first place, that our tool makers are as busy as they have probably never been before, which would show that in the unprecedented demand that the world is now making for machinery, we are getting our full share, or, at any rate, as much as we care to take, and that where we have built machines on American lines, we have been able to more than hold our own; but the danger lies in the event of the boom breaking, when it will be found that we have got an increased competition to face. This nation is a nation of engineers, and will, doubtless, overcome the difficulty which will then present itself; but it is not indicative of a want of patriotism to call attention to facts, which, although unpleasant, have got to be faced. History would show that great industries have sometimes passed from one nation to another, and that times of widespread prosperity not infrequently form the period of their transition.

It has often been stated that American machines are merely copies of ours, and doubtless this is largely true, but some combination or slight

improvement has in many instances greatly enhanced the value of a machine. This is very noticeable in the semi-radial drilling machine, which is now illustrated. At first sight this would appear to be a pillar drill of ordinary design, but on closer inspection it will be seen that the spindle head is caused to slide on a column which rotates on balls, thus giving a radial notion to the spindle, which, together with the circular motion of the table, produces accurate work and ease of manipulation, and combines many of the best features of both the ordinary upright and radial drill. The table is provided with rising and falling motions, and is also mounted on a ball race, which permits of easy rotation even when heavily loaded. The knee carrying the drill table is gibbed to the base, and is elevated by crank, bevel gear and screw, placed directly under the centre supporting the weight, and ensuring great rigidity in heavy work. The power feed has three changes, with automatic stop motion, and the drill head has a quick return, and is balanced. The machine weighs a little over one ton, and will drill in the centre of 26 inches diameter.

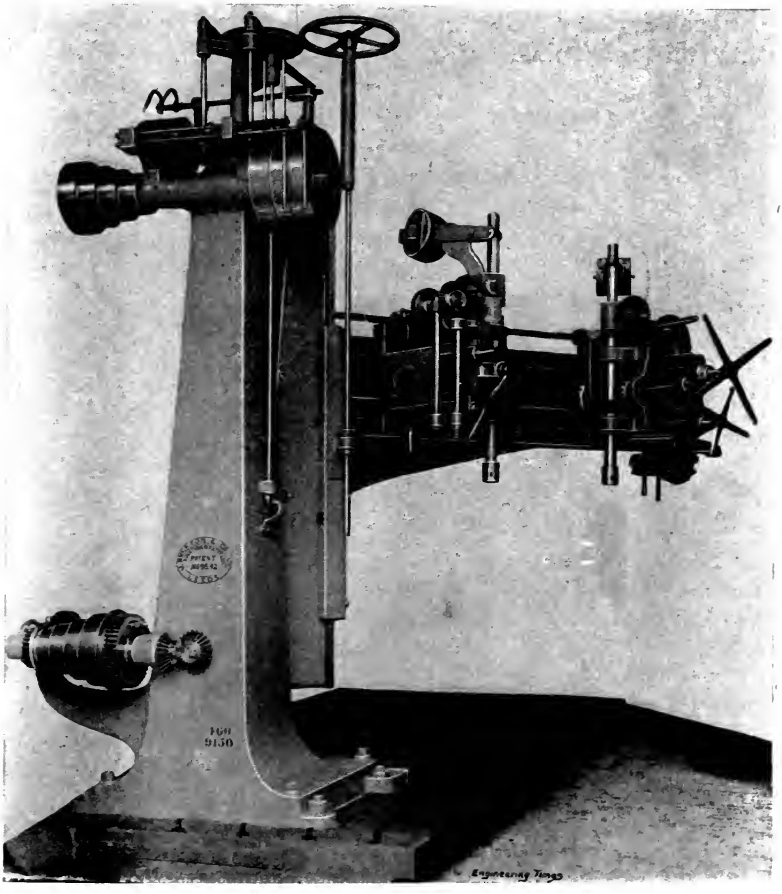


SEMI-RADIAL DRILLING MACHINE, POSSESSING SEVERAL NOVEL FEATURES.

Messrs. J. Buckton and Co., Ltd., Leeds, are one of the oldest and best known firms of machine tool makers in this country, and have a reputation for keeping pace with modern practices. The illustration herewith shows one of their Patent Two Spindle Radial Drilling machines designed to drill two holes simultaneously and over a range of 7in. to 5ft. apart, on work up to 7ft. high from base plate. The jib can be raised and lowered rapidly by power with a travel of 3ft., and

both spindles will reach to 7ft. radius, the jib swinging through an arc of 180°. The spindles are 2½in. diameter with variable self-acting feed balanced by counter-weight and with quick hand adjustments, and each spindle has 12in. adjustment at right angles to the main jib. The two spindles drilling and tapping as well as the power driving for raising and lowering the arm are all self-contained, and the reversing handle is situated upon a shaft running along the arm is a convenient position for the workman.

This machine will turn out more

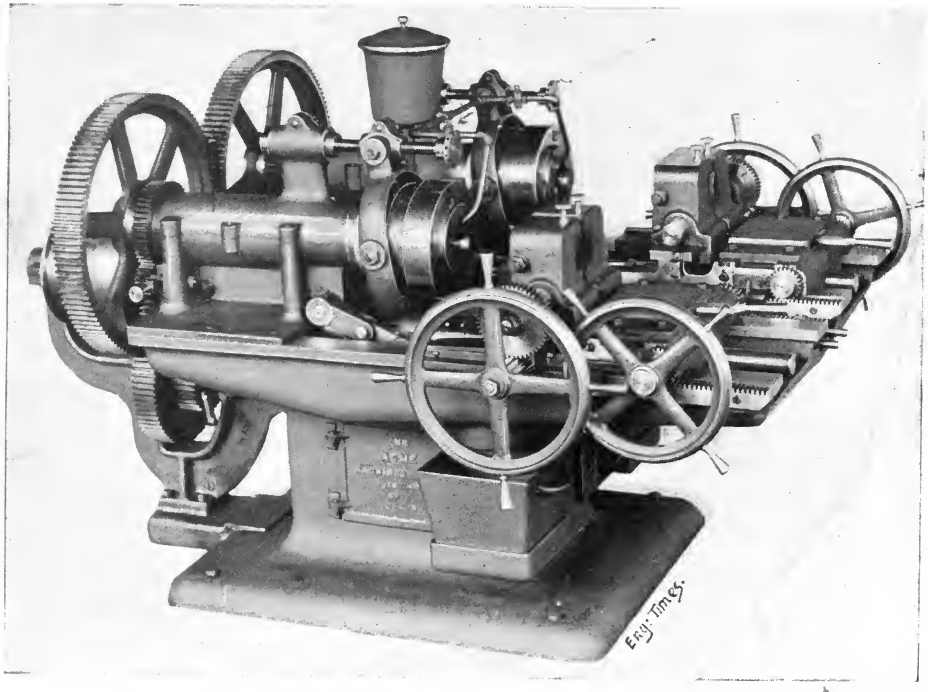


PATENT TWO-SPINDLE RADIAL DRILLING MACHINE.

can be quickly moved or fed together or the feed action of either can be disconnected at will. Each of the secondary jibs can be quickly traversed upon the main arm, and each spindle head stock can be traversed upon its own jib. Counter-driving apparatus and reversing gear for than twice the amount of work in a given time than a single spindle machine, and is able to drill simultaneously two holes, however irregularly they may be situated with regard to one another as long as they are within the limits of the machine. The adjustment of each spindle is

independent of its fellow and is effected by two rectilinear movements, while the thrust of the spindles and the weight of the arm are carried upon specially designed ball bearings with hardened steel races and ball retaining cages.

The method of driving the spindles by means of right and left hand skew bevel gear enables the spindles to be brought to the close pitch of 7in., agents in this country. As will be noted on reference to the illustration, the machine is double-headed, and will thread or tap two pieces of work at the same time from $\frac{3}{4}$in. to $2\frac{1}{2}$in. diameter, with either right or left hand threads. Strength, durability, and simplicity are features which every machine should possess, but they are absolutely indispensable in screwing machines. In the "Acme"



THE "ACME" DOUBLE BOLT CUTTER.

while retaining ample diameter of driving gear. The machine is applicable to all classes of work for which the ordinary radial is used and will turn it out twice as quickly.

Another machine possessing some interesting features is the "Acme" Double Bolt Cutter, as made by the Acme Machinery Company, of Cleveland, and for whom Messrs. Burton, Griffiths, and Co., of London, are the machines the special features are—(1) the die head, which is of exceedingly simple construction, being confined to three principal parts, all of which are made to standard gauge and interchangeable; (2) lead screw and power feed attachments; (3) special pump arrangement for supply of lubricant to the dies, giving a variable quantity, as desired.

The machine illustrated, which can

be worked by one man, will do the work above specified, and weighs about three tons.

Improvements in milling machines are so rapid that it is difficult to get hold of the latest thing. Owing to the variety of work this type of machine will do, it becomes an important matter to have a large range of feed, and, at the same time, to be able to rapidly change from one feed to another. This besides being convenient, also insures that the utmost amount of work will be got out of the machine. The Garvin Machine Company, of New York, for whom Messrs. Burton, Griffiths, are the agents here, make the machine herewith illustrated. In this machine eighteen changes of feed are provided and any particular feed is instantly obtained by simply turning a handle to the corresponding number on the index disc, seen clearly on the side of the column. All these changes apply to each of the several feed motions, and all of which are reversible.

THE GARVIN MILLING MACHINE.

There is a gear box set inside the column, and the feed is driven positively by a bicycle chain in place of belts. A slip friction ensures safety in case of carelessness in over-running. The machine is fitted with ample lubricating arrangements, and is a powerful, serviceable tool.

(To be concluded in next issue.)

Ewart S. Amos

MODERN GAS ENGINES.

By HERBERT PARKER.

III.—*THE VERTICAL TYPE—SELF-STARTERS—THE FUTURE OF THE GAS ENGINE—CONCLUSION.*

THERE are a number of people who are prejudiced against the vertical engine.

They consider that the fly wheel and driving shaft are too high ; that the base is insufficient, and, that if power is taken from a shaft placed at such a height, there will be great danger of pulling the engine over altogether.

They forget that man himself is but a vertical atmospheric gas engine, that his base is small, his centre of gravity is high, and so on. Indeed, every objection that could be raised to the vertical gas engine, might be brought with equal force against the lord of creation himself.

It is useless to point out scores of cases where such engines have been working for years and giving every possible satisfaction. The prejudice is there, and you cannot remove it ; arguments, proofs and facts are alike thrown away. The English mind loves prejudices, but whether they are sane or not it enquires not, and matters less—to the English mind.

INVERTED VERTICAL ENGINES.

There is, however, one type of vertical engines to which no such objections—imaginary or otherwise—can be taken, viz., the inverted vertical.

In this case the centre of motion may be placed as low as you care to have it, and the base may be as large as you can find room for. We will now give a few examples of this type of engine.

The "Duplex" Gas Engine (Fig. 8), by S. Griffin and Co., Kingston Iron Works, Bath, is entirely new, both in design and arrangement of details.

The essential novelty consists in the combination—in a single water jacket—of two cylinders, parallel to each other.

The cylinders are fitted with two long pistons, rigidly joined at the outer ends by a light steel crosshead of box section. Attached to the latter is a connecting rod, which actuates a crank in the usual way.

The water jacket extends over the cylinder covers, and here are fitted the inlet and exhaust valves, which open direct into each cylinder. The valves are operated by ordinary rocking levers, which receive their motion direct from a single crown cam, mounted on the end of a vertical shaft, driven from the crank shaft underneath by a two to one bevel gearing.

Governor gear, which is of specially sensitive design, actuates a single gas valve, which supplies both cylinders. There is no graduation of the charge by step gearing, the contact pieces being of the positive hit or miss type. Thus the highest possible economy

is insured under every variation of load.

Compression of the charge is carried to about 45 lb. per square inch, the mean working pressure being 82 lb. per square inch. Both cylinders are 10¼in. diameter by 15in. stroke. At 180 revolutions per minute, this gives 46 i.h.-p., and a b.h.-p. of 40. The consumption of gas per i.h.-p. is 18½ cubic feet, and per b.h.-p. 21½ cubic feet. Although engines of this type are working at 46 i.h.-p., they are so designed that they can easily be driven at 200 revolutions per minute, when they will develop 80 i.h.-p.

A high mechanical efficiency (over 86 per cent.) is obtained, and this is chiefly due to three causes :—Firstly, the vertical arrangement of cylinders, by which friction is reduced to a minimum ; secondly, the perfect system of cylinder lubrication, by means of which the oil is delivered to, and gravitates from, the inner to the outer end of the pistons ; thirdly, to the fact of obtaining an impulse at each revolution without the addition of extra weight or gearing of any kind beyond that required for an ordinary double cycle engine of the same size of cylinder, *i.e.*, of half power.

Its high thermal efficiency is due chiefly to two causes, viz :—Firstly, the entire water jacketing of the combustion chambers and passages. By this means the working charge is kept at the lowest possible temperature before ignition, in order to allow the greatest possible range or fall of temperature during the expansion of the ignited charge. Secondly, the absence of all ports or passages between the valves and the combustion chamber, thus ensuring the least possible loss of heat by conduction after ignition.

The crank pin and tail pin of the connecting rod are oiled from two sight feed lubricators fixed to the water jacket, the oil, by means of suitable pipes, gravitating from wells on the crosshead to each bearing. Constant and perfect lubrication of these two important bearings is thus secured for any length of run, a most important point in electric light engines.

When running at the comparatively slow speed of 180 revolutions per minute, these engines are so free from either mean or cyclical variations that they give a practically steady light even when running at a quarter load, the variation in no case exceeding 1 per cent. They have also the advantage that very little ground space is required, while their extreme portability when dismounted renders them specially suitable for export, or employment in positions that are limited in area or difficult of access.

THE WESTINGHOUSE ENGINE.

It is a well-known fact in the engineering world that the attendant on a Westinghouse engine, no matter how large, has absolutely nothing to do. The engine takes care of itself.

Should a drop of oil be wanted, the engine takes it. If a set screw requires tightening up, the automatic slack adjuster takes the matter in hand, and all is right as right can be.

The attendant is usually depicted reclining in a comfortable easy chair, with his legs at an angle of 79½ degrees with the horizon, his back to the motor, serenely blowing his " bacca," while studying the latest sporting intelligence in his favourite newspaper.

Mr. Edwin Ruud, of Pittsburg, tells us that, early in 1898, a gas engine of the inverted vertical type of about 650 b.h.-p., was completed in the works of the Westinghouse Machine Company.

This engine has three cylinders, and the speed is 150 revolutions per minute. After it had been tested, it was erected in the power house of the Westinghouse Electric and Manufacturing Company, where it is running in regular commercial service of a severe character.

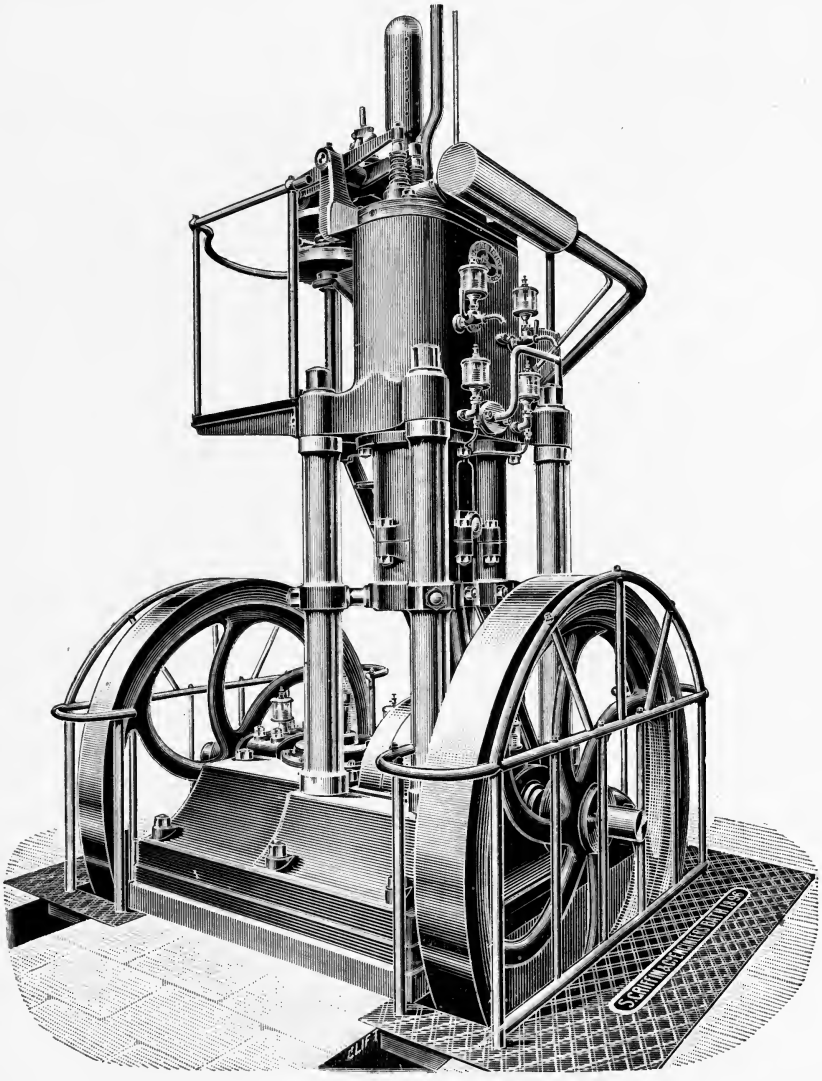


FIG. 8.—THE DUPLEX GAS ENGINE.

The engine is connected direct to a suitable electric generator, and runs in conjunction with one or two steam engines, according to the call on these units for electric current. It is the largest gas engine in the world, but it will not enjoy this distinction for a very long period. The Westinghouse Machine Company are now making drawings and patterns for a 1,500 b.h.-p. gas engine. This one is also of the three-cylinder type, and

the speed is to be 100 revolutions per minute. Great economy is expected from this wonderful engine, as every possible care is being taken to make it a model of modern gas engine construction. It is hoped that a brake horse-power will be developed for every $8\frac{1}{2}$ cubic feet of natural gas consumed per hour, or 8,500 British thermal units per brake horse-power per hour. This would give a heat efficiency of $\frac{2}{8}\frac{5}{5}\frac{6}{0}\frac{4}{0} = 30$ per cent. at the shaft.

A gas engine of such size and efficiency will run day in and day out on less than 1lb. of coal, burned in a good producer gas plant per brake horse-power per hour. This includes banking of fires and similar losses. It would have to be a good steam engine and boiler plant that would be able to produce regularly a brake horse-power per hour on 2lb. of coal—that is, twice the amount of fuel required by a gas engine working under similar conditions. And so it appears that a gas engine can hold its own as a prime mover, and can be used for almost all the purposes for which a steam engine is employed.

THE DAIMLER MOTOR.

This engine (see Fig. 9) by the Daimler Manufacturing Company, of Long Island City, New York, was formerly intended to be operated by gasoline and illuminating gas. At the present time it is, however, so constructed that common kerosene oil can be used to advantage, and with the same efficiency. The Daimler engine is now being fitted to a large number of street cars, and it is, we believe, a very satisfactory motor.

It is of the two cylinder inverted vertical type, and all the working parts are enclosed. The oil, or spirit which may be used, is contained in a suitable tank, or reservoir. When

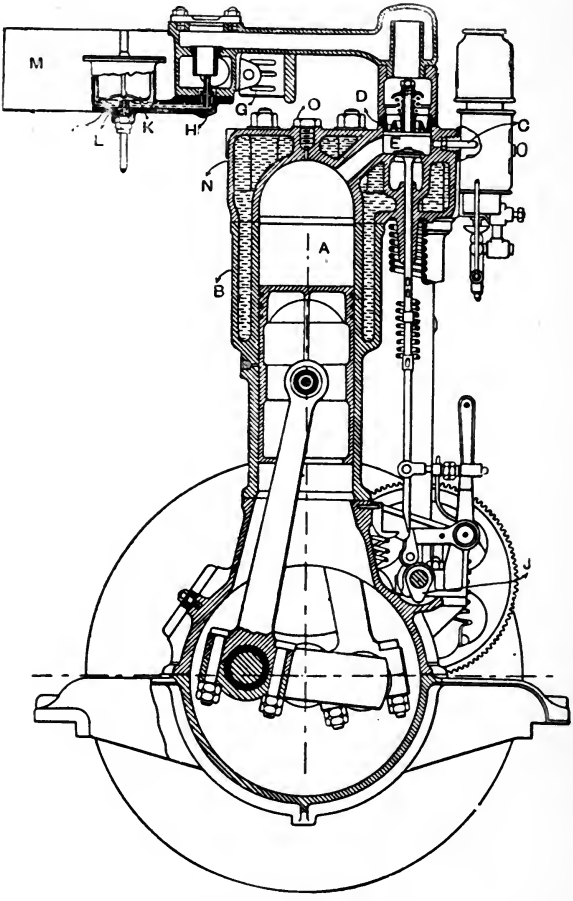


FIG. 9.—THE DAIMLER MOTOR.

starting the motor, air is pumped into the tank by hand in order to supply the necessary pressure to force the oil up to the float chamber F, and the lamps required to keep the platinum ignition tubes hot. After the engine is running a small portion of the exhaust is allowed to escape

into the reservoir, and, in this way, the needed pressure is maintained. On the outward stroke of the piston a slight vacuum is formed in the cylinder A. The valve E, which is entirely automatic, being held up to its seat by a spiral spring, opens, and allows air to flow through the slots G along the horizontal pipe through the valve E, and into the cylinder. At the same time the spirit is sucked through the nozzle at H, and mingling with the air, enters the cylinder to form the charge. On the return stroke of the piston the gases are forced into the ignition tube C, there ignited, and impel the piston forward. The exhaust valve shown at E, is operated by a cam J through a hit-and-miss arrangement by which the exhaust may be held open for the purpose of governing the speed of the engines. The lamp or burner shown in the illustration explains itself.

The important point is that the light cover surrounding the upper casing of the wick acts somewhat as a chimney, and causes a thorough mixture of air and spirit vapour, which results in perfect combustion. A pump is used to keep the water in circulation throughout the jacket. It will be observed that there is no timing valve to regulate the ignition of the charge. It is, therefore, of the utmost importance that the exhaust and admission valves be kept perfectly tight, as otherwise the charge would escape at these outlets, instead of being compressed with the ignition tube C. The Daimler Company recommend that the valves should be taken out occasionally, washed in petrol (the name given to the gasoline product of petroleum), and carefully ground with fine pumice dust.

There does not at present appear to be any authentic tests published on the performance of the motors from a thermo-dynamic standpoint. The motors run at about 500 revolutions per minute.

SELF-STARTERS.

Undoubtedly, when dealing with the larger size of engines it is a great convenience to have some means of starting readily. It is so easy in the case of smaller sizes, to give the fly wheel a few turns by hand, that we do not miss anything.

But large bodies move slowly, and, when a certain size of engines is arrived at, the effort of moving them becomes considerable, and it is here that the want of a self-starter is first experienced.

Although not wishful to advocate any particular form of self-starter, when there are several good ones to choose from, I may perhaps be permitted to select one of these to represent the rest.

The Edmondson and Dawson starter (see Fig. 10) by Joseph Edmondson, Albert Electrical Works, Bradford, Yorks, gives an initial impulse automatically according to the requirements of the engine at the time, and follows this up by a further impulse at each cycle until the ordinary ignition apparatus of the engine takes up the running, when the starter may be thrown out of gear.

At the slow speed of starting by any self-starter, the proportions of gas and air in the charge drawn into the cylinder is frequently not ignitable by the tube, hence the difficulty of starting an engine by a single initial impulse. By this starter a flame is injected into the midst of the charge, and it will therefore ignite a mixture, so badly proportioned, that the tube would fail to fire it.

Hence ignition is certain, and successive impulses are given to the

piston ; and the engine runs, in spite of the temporary failure of the tube.

The action of the apparatus is as follows :—The engine being set on the "explosion stroke" with the gas cock turned on, and the crank a little behind the top centre, the starting cam B having the square stud Q standing on its "jumping off place ;" a few strokes of gas are pumped into the cylinder by the pump F. The pumping being continued, with gas and air—forming an explosive mixture—the charge isslightly compressed till it propels the piston slowly forward, and moves the cam B a little—clockwise—drops the roller P into the gap of the cam and releases the lever M. The spring R then rotates the plug of the ignition valve towards the right, ignites the charge in the cylinder, and propels the engine.

If the pumping be still continued gently—one stroke for each cycle—so as to keep the connections between the pump and cylinder full of explosive mixture, the revolution of the cam B, by opening and closing the ignition valve, and exploding the charge at the proper times will give successive impulses to the piston, increasing its speed until the engine is effectively started.

The starter may then be thrown out of gear, by pushing the handle T of the lever M to the left, when the catch U falls down and holds the lever so that the roller P stands free of the cam B, and the action of the starter ceases.

THE FUTURE OF THE GAS ENGINE.

Ante victoriam ne canas triumphum. It is notoriously unwise to predict until after events have occurred ; but, in conclusion, I must hazard a few words on the future of the gas engine.

The efficiency of the gas engine, to begin with, was certainly low enough. By the introduction of the compression principle, its efficiency has been very greatly increased. It does not seem reasonable to hope for much greater improvement in this particular direction. The steam engine has been improved almost as much as it possibly can be, but what improvements are in store for the gas engine, who can say? High as it already stands, there is ample room—in the field of expansion—for such further efficiency, as will place it far ahead of anything that can be hoped for from the steam engine. Even now the gas engine throws away pressures, more than sufficient to keep a steam engine going. Already excelling the steam engine in some points when these pressures are rendered available

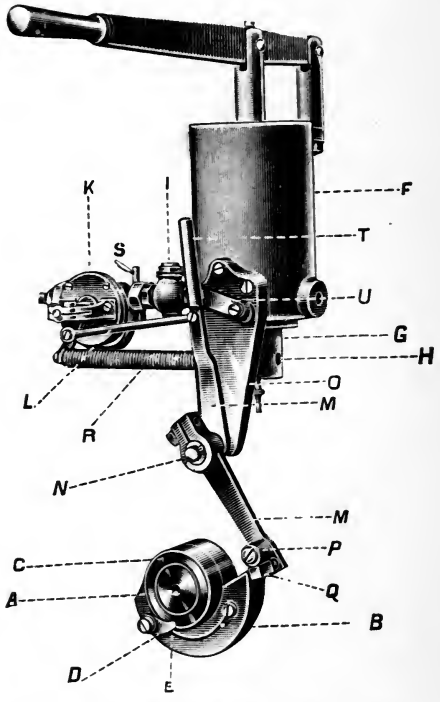


FIG. 10.—THE EDMONDSON AND DAWSON STARTER.

for work, as they certainly will be, what will be the result?

The consumption of gas per horse-power has been very considerably reduced, and we may look with some confidence for a further reduction in the price of that commodity, which, after all, is only a waste product.

We believe there is at least one town in Great Britain whose citizens are supplied with gas free of charge, and this any corporation could well afford to do; the profits arising from the other products of gas manufacture being so very large.

A recent offer of the Brookline Gas Light Company, of Boston, Mass., is of some importance in this connection. This company is prepared to furnish coal gas of 18-candle power, containing less than 10 per cent. CO, for engine use at a rate of one and a fifth cents per horse-power per hour for engines of 100 h.-p. and less. For engines of from 100 to 200 h.-p. one and one-tenth cents will be charged, and above 200 h.-p. *one cent* per horse-power will be the rate, which is very cheap—for America.

The president of this gas company, in making a comparison of costs, gives the present rates for electricity as from three and one-half to seven and one-half cents per horse-power per hour.

Everything points to a brilliant future for the gas engine. The prospects are most encouraging. The good old steam engine appears to have reached its highest possible state of efficiency while the young and vigorous gas engine still advances with rapid strides.

The conclusion to many minds is irresistible; sooner or later the gas engine must supersede the steam engine, and not only that it must but that it will.

Herbert Parker

AERIAL WIRE ROPEWAYS

THEIR DEVELOPMENT, USE AND CONSTRUCTION.

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WIRE ROPEWAYS ON SIX SYSTEMS APPLICABLE TO ALL SITUATIONS AND REQUIREMENTS.

By W. T. H. CARRINGTON, M.Inst.C.E.

WHERE properly applied, well made, and the right system selected, ropeways can do excellent work and prove themselves superior to other systems of transport, both in first cost and working expenses.

It must, however, be understood that no one system can be universally adaptable, and it is through such attempts that the discredit which befell this means of transport in earlier days is no doubt largely due.

The circumstances which should decide the type of ropeway to be used are many, *e.g.* :—

(1) The character of the country which has to be traversed ;
(2) The class of materials to be transported ;
(3) The manner in which such materials can be packed ;
(4) The motive power available ;
(5) The inclines to be surmounted ;
(6) The spans to be crossed ;
(7) The quantity of materials to be carried per day.

It must be clear to anyone acquainted with the working of wire ropeways that, for steep inclines, long spans, heavy individual weights, etc. one type of ropeway will always present advantages over other types. In this way, in each case, advice should be given to the purchaser as to the selection of the best system for the work he requires to do, and the situation in which he contemplates to work, so as to ensure a thoroughly satisfactory result.

The following are the systems of wire rope transport now in practical operation :—

(1) The ENDLESS-RUNNING ROPE, with carriers hanging therefrom and moving with it through frictional contact.
(2) An ENDLESS ROPE, with the carriers hanging therefrom and moving with it, being rigidly fixed in position on the rope.
(3) The FIXED ROPE, in which the carriers are drawn along and hang from a fixed rope, which acts also as a rail, returning on a parallel rope.
(4) The SINGLE-FIXED ROPE, in which one carrier is drawn to and fro, hanging from a fixed rope, by means of an endless hauling rope.
(5) The use of TWO FIXED ROPES, with an endless hauling rope, in which one carrier travels in one direction, while the other runs on a parallel rope in the opposite direction. This is a thoroughly serviceable type of tramway, capable of being used over extremely long spans, and of carrying loads up to 5 tons.

(6) The use of ONE FIXED ROPE placed on an incline, on which carriers, uncontrolled by hauling ropes, from which are suspended loads, are allowed to run down at a high speed. This is generally called a "shoot."

Having all these systems at command, it is necessary to study the situation in which the ropeway is required to be operated and the work it has to perform, and to adopt one of the five systems named above. This is the course the author has always followed.

(1) The ENDLESS-RUNNING ROPE, with carriers hanging therefrom and moving with it through frictional contact, is most suitable under the following circumstances :—

Where the quantity to be carried does not exceed 500 tons per ten hours ; where the inclines do not exceed 1 in 3 ; where the individual loads do not exceed 6 cwt. ; and also where the section of ground does not necessitate spans of greater length than 600 ft. ; longer spans, steeper inclines, greater quantities, and heavier loads can be carried by this system, but not so advantageously as by another system referred to hereafter.

This system of ropeway is arranged as follows :—A driving gear at one end, fitted with a driving drum, varying from 5ft. to 10ft. in diameter, and arranged with suitable gearing for receiving the power—steam, water, or even horse-power in the case of smaller lines. At the opposite terminal a similar wheel is placed and provided with tightening gear. Round these two wheels an endless band of wire-rope is placed. Intermediately between them the wire-rope is carried on suitable pulleys of diameters varying according to the size of the rope, the former being carried on posts of iron or timber, spaced about 200ft. apart, and of suitable height to enable the carriers to clear intervening obstacles, and also to regulate, to a certain extent, the general level of the line. The carriers hang from the rope, and are enabled to pass the supporting pulleys by means of a curved hanger, which, pivoting in the V-shaped saddle which rests on the rope, attaches at the lower end to the receptacle by means of a hook. The saddle, in an iron frame, is fitted with wood or rubber, or composition friction blocks, by means of which the necessary friction on the rope is obtained, which enables the carrier to pass with the rope up steep inclines and over pulleys.

The frame which carries these friction blocks is usually made of malleable cast iron, and has wings at each end, which, as the carrier arrives at the supporting pulley, embrace the pulley rim and pass over it. The limit of incline workable under this arrangement is probably about 1 in 3 ; other devices may be used for working over steeper inclines, but such involve a reduction in the lasting power of the ropes, and in such cases it is better to use the fixed rope system.

The frame which carries these friction pieces is fitted with two small wheels, carried on pins attached to it, which are called shunt wheels, and are employed for removing the carrier from the rope at the terminals and at curves, where shunt-rails are placed. These rails are held in such a position that when the carrier approaches the terminal the small wheels engage on it, and, running up

FIG. 1.—VIEW OF A ROPEWAY IN WARWICKSHIRE, 1¼ MILES IN LENGTH, CARRYING 200 TONS OF IRONSTONE PER DAY, SHOWING UPPER PORTION OF LINE PASSING OVER ROUGH GROUND TO LOADING TERMINAL.

a slight incline, lift the friction or clip-saddle from the rope and enable it to pass to where the loading and unloading is required to be done, or round the curve wheels. The impetus derived from the speed of the rope (about four miles per hour) is sufficient to enable the carrier to clear itself automatically from the rope without difficulty. Thus, we see that the first system consists of an endless wire rope driven by suitable gearing, with carriers hung on the rope, travelling with it either by means of friction or mechanical clips.

Examples of this system of ropeway are shown on the illustrations (Figs. 1, 2 & 4), viz., that of a line of about 1½ miles in length in England, capable of transporting 200 tons per day of ten hours.

One of the illustrations of this line (Fig. 2) shows an arrangement of shelter bridge as required by the County Council to hide the ropeway where it passes over a public road. The view fully illustrates the nature of any such structure which may be necessitated where a ropeway crosses a public road or railway.

Another illustration (Fig. 4) of this line represents how a change in the vertical direction of the country may be surmounted without the use of any special apparatus. The rope, it will be seen, takes the form of a large vertical curve in passing from the level ground to a terminus at a higher elevation. This arrangement of vertical curve may, with care, be carried out on a much larger scale, so as to enable variations in the ground level, where they are too large to be spanned between two supports, to be worked over without fear of the ropes leaving the pulleys placed on the posts to support them.

The above-named illustrations represent examples of this system of ropeway, of which some several hundred miles have been erected by Messrs. Bullivant and Co., Limited, in conjunction with the author, in various parts of the world. Of these, perhaps it is only necessary to refer to Mauritius, where some thirty miles are at work carrying sugar-cane, etc.; to India, where a number are at work for various purposes. Similar lines exist in many other parts of the world.

Respecting the lasting power of the ropes, which are the chief wearing parts and the most expensive to renew, it may be of interest to state that on a line in Spain constructed on this system, carrying 300 to 350 tons per day over a length of one mile, the rope carried over 160,000 tons. This represents an outlay of about ¼d. per ton per mile for rope renewal. See illustration (Fig. 3).

Including renewals of wear and tear and labour, but not fuel, the average cost per ton per mile for transport, may be taken as varying from 2d. to 4d.

(2) An ENDLESS ROPEWAY, with the carriers hanging therefrom and moving with it, being rigidly fixed in position on the rope. This second system is similar to the first in some respects, and is especially suitable where very steep inclines and sudden and continual changes of level have to be operated over. The incline on which this system of ropeway can be worked seems to have no limit. As guard or depressing pulleys may be placed wherever necessary, without obstructing the passage of carriers, the vertical angle of the line may change at each post. It has the driving gear, the tightening gear, the

FIG. 2. VIEW OF A ROPEWAY IN WARWICKSHIRE, 1¼ MILES IN LENGTH, CARRYING 200 TONS OF IRONSTONE PER DAY, SHOWING GUARD OVER HIGH ROAD AS REQUIRED BY THE COUNTY COUNCIL.

endless rope and the pulleys, as in System No. 1, but the carrier does not rest on the rope, but is clipped to it by means of a steel band which embraces it, tightened by a convenient arrangement. The position of the carriers, therefore, is fixed ; they are placed in position, and where the rope goes they must go. As a result, at the terminals, they must go round the terminal wheels. The driving wheel is generally in the form of a special clip drum, and the terminal wheel, where the tightening takes place, is arranged so that the passing round of the carriers is easily effected.

Unloading can be readily done by allowing the carrier to strike a catch, causing the bucket to capsize or open at the bottom. Loading, however, is a more complicated matter, and devices, both ingenious and more or less efficient, have been devised for loading the carrier, either while it passes round the driving drum, or at a point adjacent thereto, *e.g.*, by means of hoppers or cages moving at the same speed as the carrier and operated by it. It is not unusual with this system to arrange the ropeway to run slowly, say, at a speed of 2 to 2½ miles per hour, in which case loading and discharging can be done without any special apparatus as the carriers pass the terminals, thus dispensing with all complicated gear.

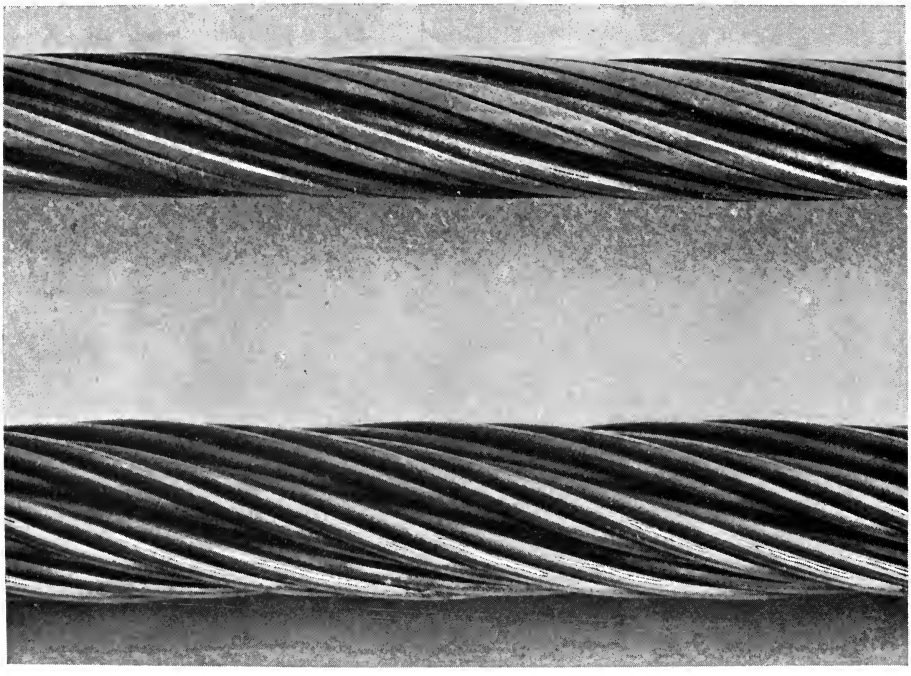


FIG. 3.

This Rope was supplied to a Wire Ropeway (Carrington's System) from Badovalle to Ortuella, and was put to work at the beginning of July, 1893: it worked continuously until July 20th, 1895, carrying 165,000 tons of Iron Ore. It was then taken off, as it was thought it had done enough work. That this was not the case is conclusively shown by the fact that the breaking strain of the Rope when new was 29 1/20 tons, and the breaking strain of the Rope when taken off, after having done such extraordinary work, was found to be 27½ tons.

Many lines on this system have been erected from the author's designs in situations where it would have been impossible to use any other. For moderate loads they have proved an excellent means of transport.

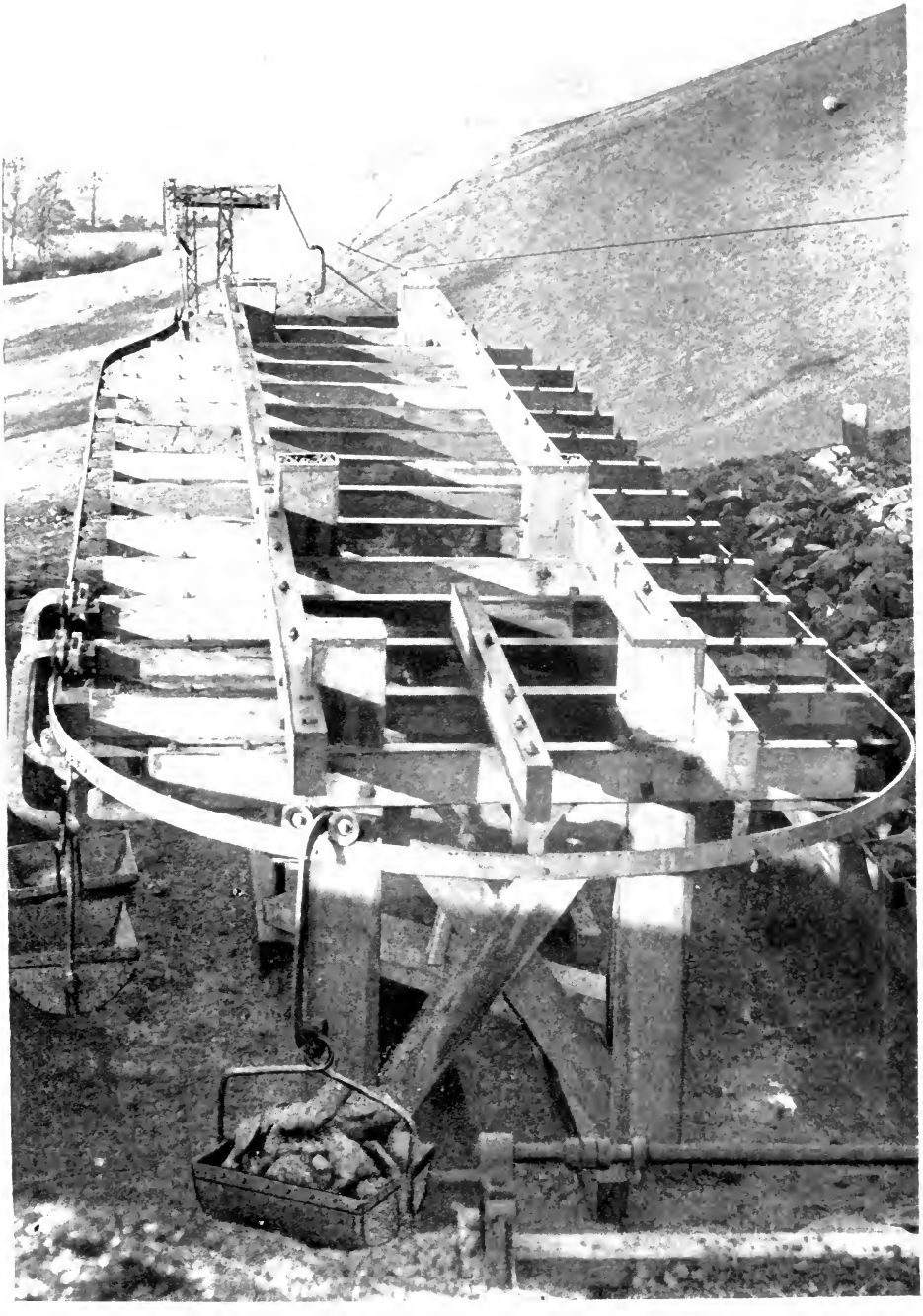


FIG. 2.—VIEW OF A ROPEWAY IN WARWICKSHIRE, 3½ MILES IN LENGTH, CARRYING [illegible] TONS OF IRONSTONE PER DAY, SHOWING LOADING TERMINAL, WITH A VIEW OF THE LINE FROM END TO END.

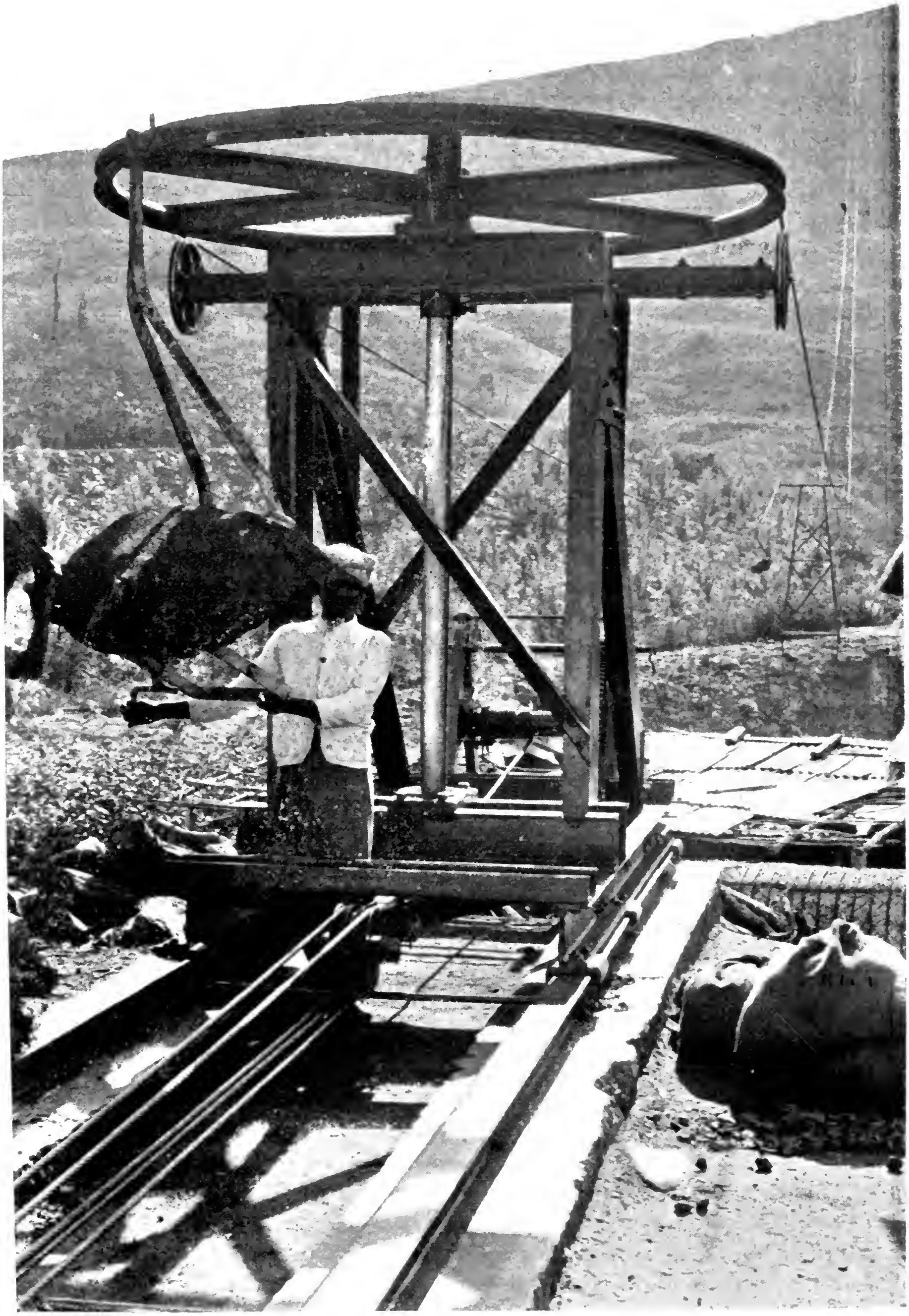
One example out of many is illustrated in Fig. 5, and represents a ropeway in Ceylon for the carriage of tea-leaf; it is about three miles in length, passing over several ridges, one having a great elevation. The leaf in bags is placed in the great carriers, which are in the form of a cage, as they pass the driving terminal. This driving terminal is operated by wire rope transmission, communicating the power required from a turbine some three-quarters of a mile distant; the carriers with the bags of tea-leaf in them travel from the driving terminal. The ground having such frequent changes in the vertical direction, necessitates the use of a considerable number of guard-wheels, by which the rope is depressed until the load passes, when its weight relieves the pressure on the guard-wheels, and enables it to pass under the guard-wheel, which again performs the office of depressing the rope. Over this section it is difficult to imagine any other system which can give, at the same cost, such a good result. This ropeway has now been at work for several years, and both in efficiency and wear and tear has given the most gratifying results. On the loads arriving at the tightening and discharging terminal, the bags of tea-leaf are lifted out of the carriers, or if desired, a projecting bar strikes the catch of the carriers, and the bags are delivered automatically.

From the illustration an idea of the nature of the ground traversed will be obtained. The labour required for working this line need not exceed four men.

(3). The FIXED ROPE, in which the carriers are drawn along and hang from a fixed rope which acts also as a rail, returning on a parallel rope. The third system of ropeway is that in which two parallel fixed ropes are used on which the carriers run, drawn along by means of a hauling rope. It should be employed where the quantities to be transported exceed 400 tons per day, except in the case where grouped lines of the first type are suitable, and where the loads exceed 6 cwt., also where the inclines exceed 1 in 3, and spans exceed 600ft.

It is economical in wear and tear, but the first cost is greater, and it does not lend itself to sudden vertical changes, and where the quantities to be transported are not large, the fourth and fifth type may be found to possess advantages.

The construction of this system of wire ropeway, is as follows:—Two fixed ropes are stretched parallel to one another about seven feet apart, being supported by posts fitted with saddles, about 300ft. apart. They are anchored at one of the terminals and tightened at the other by suitable gear. On these fixed ropes the carriers run as on a rail, being fitted with running heads carrying steel grooved wheels, in which the hanger is pivoted from which the receptacle hangs. These carriers are moved at a speed of from four to six miles per hour, by means of an endless hauling rope, operated by suitable driving gear at one end and controlled by a tightening gear at the other. The attachment of this hauling rope to the carrier is an essential point, as it must be made by means of an automatic clip which will release itself on touching a bar on arrival at the terminal station, and at the same time will hold sufficiently tight to enable the hauling rope to drag the carrier up any steep inclines which may



VIEW OF A ROPEWAY IN CEYLON, ABOUT [illegible] MILES IN LENGTH CARRYING TEA-LEAF, SHOWING DISCHARGING TERMINAL.

[illegible]

occur. This is done by forming a knot in the hauling rope, or putting a sleeve round the same, or a suitable casting inside the rope at certain points, so as to make an enlargement at the point on which the clip engages by a suitable device ; all these devices result in undue wear. A better arrangement is that of a clip by means of which the hauling rope is held simply by pressure resulting from the operation of wedges acting on inclines or screws. This method is certainly far superior to any device of knot or sleeve attachment to the hauling rope, and gives better results in the working of the rope. Where the inclines are only slight, simple pressure may be used by pressing two pulleys or plane surfaces together on each side of the hauling rope. This system has answered sufficiently well where the pull on the hauling rope is slight, but where the incline is great, the type of clip in which the attachment results from the use of an incline or wedge must be used.

This system of line has shunt rails, driving and tightening gears, in common with the first-named system. At each of the supports, rollers have to be provided, in which the hauling rope rests where it sags between the carriers. These rollers are provided with guide bars to increase the range of support which guide the hauling rope, should it be deflected from the vertical, into the above named pulleys.

Among the examples of this system of line may be mentioned a ropeway in Japan, of which illustrations (Figs. 6 & 7) are annexed. This line, about 1,800 yards in length, for the greater part on an incline of 1 in $1\frac{1}{2}$, is employed for the carriage of ore from the upper terminal to the lower. Such is the power generated by the descending loads that it is necessary to absorb the greater portion of it and thus render the line amenable to the control of a hand brake. For this purpose a water brake was introduced in which a revolving fan drives the water against fixed vanes which again repels it. In this way some 50 h.-p. is absorbed and the speed of the ropeway can be regulated to a nicety by adjusting the reaction vanes against which the water impinges. A small supply of cold water is provided, to keep the temperature of the water employed in the brake at a sufficiently low temperature. Illustrated details of this ropeway indicate the position of the above named brake, etc. Ropeways on this system have been constructed by Messrs. Bullivant and Co., of London, from the author's designs, in various parts of the world, and notably we may refer to one in Peru, having a length of nearly two miles on an incline of 1 in $1\frac{1}{2}$. The nature of the ground traversed is very severe, and the application of the clip named above, together with suitable gear, has caused the line to work in a most efficient and satisfactory manner.

(4) The SINGLE FIXED ROPE, in which one carrier, hanging from a fixed rope, is drawn to and fro by means of an endless hauling rope. The fourth system, or single fixed rope with one carrier, was introduced by the author, and is most suitable in situations where moderate quantities have to be transported in heavy loads or pieces, and where spans of considerable length have to be worked over. With this system, inclines up to 1 in 1, or even steeper, can be worked, spans up to 2,000 yards may be operated, and loads up to 5 tons may be dealt with. It is cheaper in first

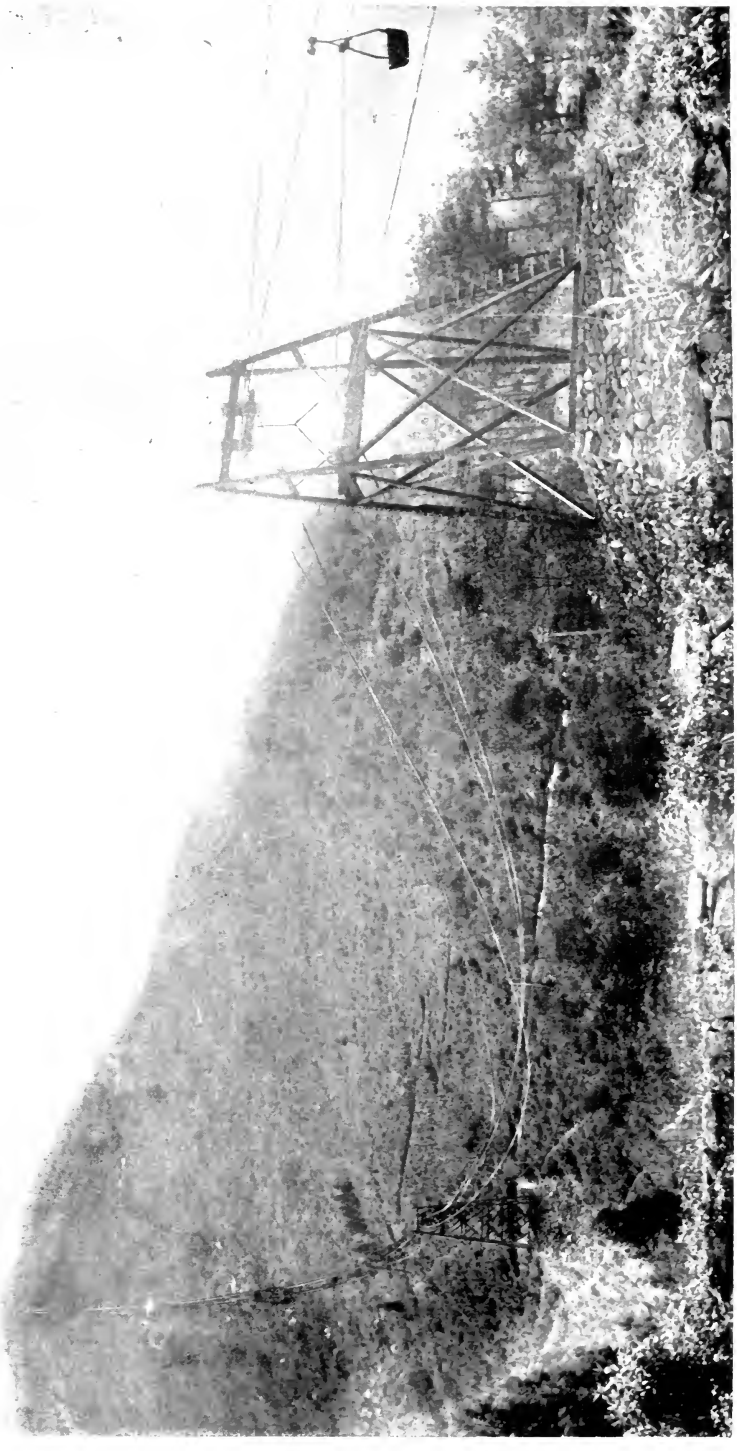


FIG. 6.—VIEW OF A ROPEWAY IN JAPAN CARRYING MINERAL FROM TOP OF A MOUNTAIN, THE INCLINE IN THE PART SHEWN BEING NEARLY 1 IN 10.

cost than the third system, and simpler to erect, and less costly to manipulate.

The arrangement consists of one single fixed rope on which one carrier is employed, the latter being drawn to and fro by an endless hauling rope, operated by suitable motive power, the driving gear being arranged with the reversing motion, so that the direction in which the carrier runs may be changed by the driver. The fixed rope is supported on posts at intervals of about 300ft., and the hauling rope is carried on pulleys fitted with guide bars, placed in the centre of the post over which the carrier passes, the posts being arranged so as to allow of the carriers passing through them. The return hauling rope is supported on an outside pulley mounted on an arm of each post. The hauling rope is attached to the carrier-head by a peculiarly-shaped pendant, which causes it to pass under the saddle transom. Messrs. Bullivant have made this type of tramway for some years for transporting large quantities over short distances, an important example being that of a ropeway on Table Mountain, 5,280 feet in length. Commencing at sea level, and following the ground on posts, spaced some 300ft. apart, the cable takes a span of 1,500ft., rising to a projecting rock some 1,480ft. above the starting point. Resting on a support at this point, the cable again makes a span of 1,400ft. to an upper terminal 62,200ft. above the lower one.

An illustration (Fig. 8) shows a ropeway on this system erected for the carriage of passengers only. This is probably the only example of a ropeway constructed solely for this purpose of any considerable length. It is situated in Hong Kong in connection with a large sugar works, in which a number of European workmen are employed, and to secure freedom from fever these men are transported at the end of their day's work to a sanatorium at a high level above the sea. The carrier is arranged for the accommodation of six men at a time. The speed of the ropeway is eight miles per hour, and as the men leave their work in batches they come to the terminal and find the carrier prepared to take them up. This ropeway has been in operation for several years, and has given excellent results and performed its work with absolute safety to those travelling on it.

Many other similar ropeways have been erected from the designs of the author.

(5) The use of TWO FIXED ROPES, with an endless hauling rope, in which one carrier travels in one direction, while the other runs on a parallel rope in the opposite direction. This is a thoroughly serviceable type of tramway, capable of being used over extremely long spans, and of carrying loads up to five tons. This system is one which is intermediate between the third and fourth, adopting the use of two parallel fixed ropes, as in the third system, but with the use of one carrier on each rope, as in the fourth system. It may be used where the quantities required to be moved are such as will admit of the ropeway being worked by gravity, one carrier descending loaded, while the empty carrier ascends unloaded. With this arrangement spans up to 2,000 yards may be made without supports, loads up to six tons may be carried, and quantities up to 100 tons per day transported. In other cases steam

power may be employed, and the loads moved from the lower to the upper terminal, while the empty carrier descends loaded or unloaded, as may be the case.

By the experience gained in the construction of a number of such ropeways, great efficiency has been arrived at, so much so that these ropeways may be relied upon to provide a safe means of transport for passengers, and the speed at which the carriers run can be very great—indeed, not infrequently amounting to thirty to forty miles per hour. The control of the line is effected by a breakgear, situated at the upper terminal, operated by one man, who can perfectly regulate the speed.

While many ropeways on this system are employed simply to span from the upper portion of a mountain over a valley to the lower side of another, others are constructed with one or more supports, and skirt the side of a steep hill. In this latter case a slower speed must be maintained, not above ten miles per hour, as the passing of the carriers over the supports at a higher speed is inadmis-

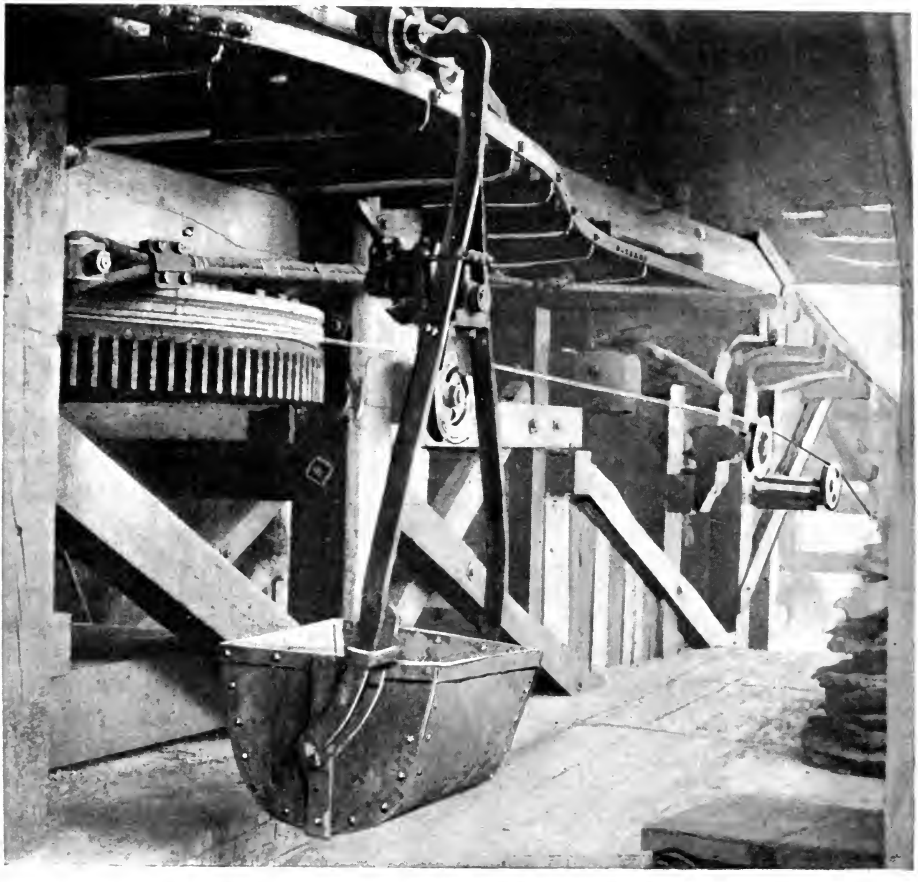


FIG. 7.—VIEW OF A ROPEWAY IN JAPAN FOR CARRYING MINERAL FROM THE TOP OF A MOUNTAIN, SHOWING A SHUNT RAIL AT THE UPPER TERMINAL WITH A CARRIER IN POSITION.

sible. As the loaded carrier is usually much heavier than is necessary to draw up the empty one, a proportionate amount of material may be transported up as well as down ; indeed, in some cases, where water is available, it is possible to run materials up alone, employing the descending carrier as a counter-balance filled with water. Where loads are required to be carried up the incline and not down, and steam power is supplied, ropeways of considerable efficiency have been constructed ; in this case an engine or other motive power operates a driving gear at the lower terminal, and a carrier containing the necessary passengers or materials to be transported moves at a speed of eight to ten miles an hour up the incline, while the empty carrier descends loaded or unloaded as the case may be.

The annexed illustrations (Figs. 9 & 10) gives examples of this type of ropeway, operated by gravity only, which are being worked in the Alps and Pyrenees. The long spans are clearly shown on these views, and an idea can also be obtained of the terminal arrangement, and a general knowledge of the utility of the system can be readily gained by studying the situation in which these ropeways have been erected. An example of this system working in the Alps is employed for the upward carriage of minerals and for military stores for the service of forts on the mountains, which are in close proximity to the national frontier. On this a succession of ropeways (three in number), a span of 1,560 yards, carrying loads of 10 cwt., has been at work for several years. Few renewals have been necessary, and the ropes, of the highest class made specially for the purpose, show but little wear and tear after some seven years' work. This will give an idea of the low cost of maintenance with this type of ropeway. Situated at an elevation of some 6,000ft. above the sea, exposed during the winter months to the force of all the elements, on ground snowed up many feet in depth. Indeed, no better example can be cited as proving, when properly attended to, the lasting power of wire rope and ropeway machinery.

Another example is that of a ropeway in the Pyrenees where a series of five sections are placed in succession, bringing ore from an elevation over 6,000ft. in height. Each of these sections is worked by three men, and is capable of transporting some 100 tons per day.

Illustration Fig. 10 represents a ropeway in which the loads are transported up hill, the ropeway being operated by power at the lower terminal. This is erected in Spain, and is daily used both for the transport of material and workmen. It has now been in operation for several years, and has proved itself thoroughly efficient. The incline is exceedingly steep, being about 1 in 1½, the longest span being some 1,100ft. Loads up to 10 cwt. are carried, but this may be increased, when necessary, to individual loads of 15 cwt.

Another excellent example of this type of ropeway is one employed for the carriage of coal from steamers lying alongside a pier and delivery of the same into a large depot in the centre of a large sugar factory. For this purpose a tower some 70ft. in height is erected where the deposit has to be made. From this tower three ropeways, as described above, are led to the quay side, at which they are anchored, and extending to the rear of the tower, are there tightened. About 1,000 tons a day can be trans-

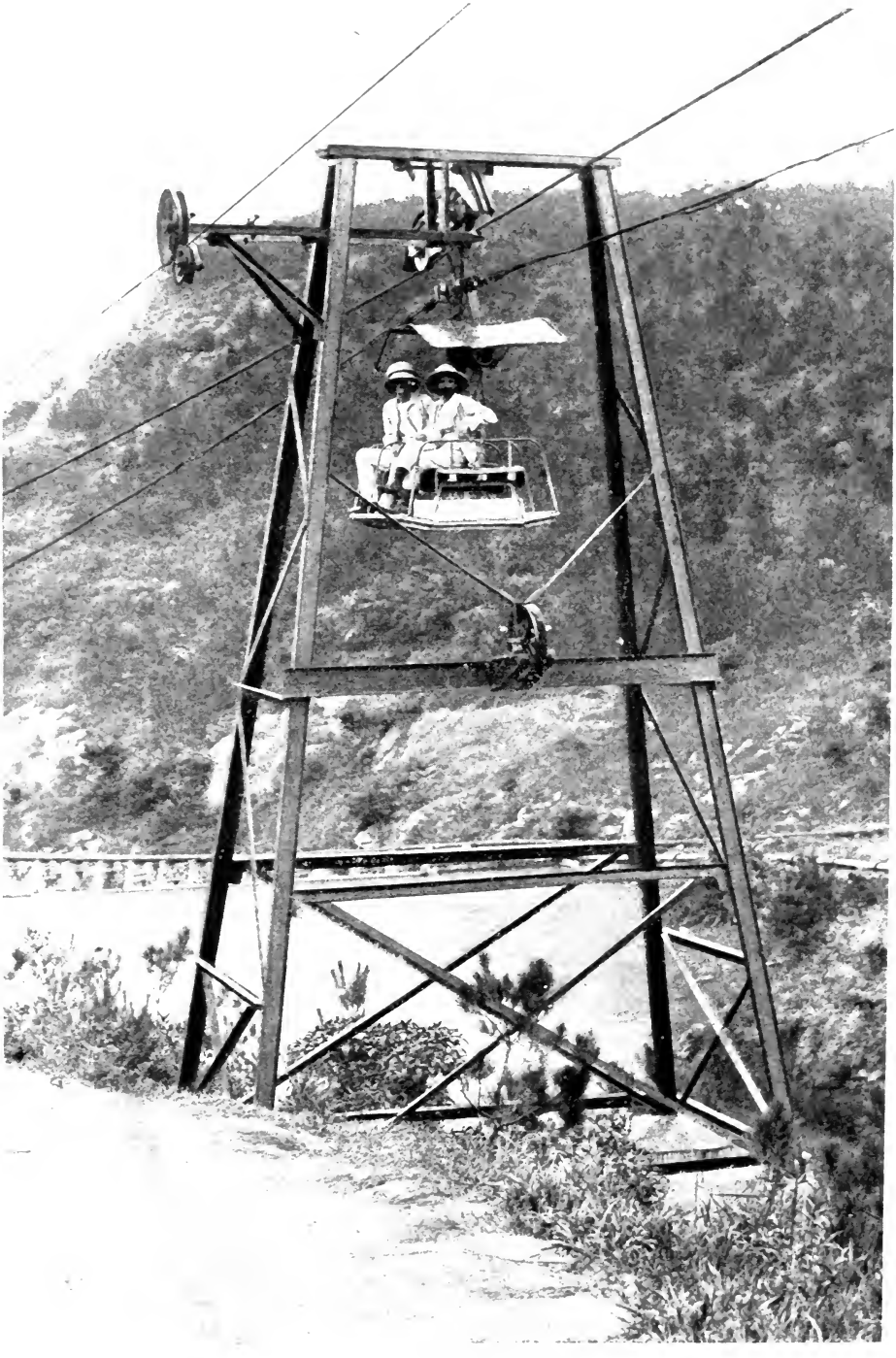


FIG. 5.—VIEW OF A ROPEWAY AT HONG KONG, ERECTED FOR THE CARRIAGE OF WORKMEN, SHOWING SUPPORT WHERE THE ROPEWAY PASSES OVER A RESERVOIR; THE CARRIER CAPABLE OF HOLDING SIX MEN IS SHOWN OCCUPIED BY TWO.

ported by this means, the engine power being placed at the top of the tower, the steam being led thereto by a pipe. The coal on arrival at the top is dumped into a hopper placed on a weighing machine, by which it is weighed, recorded, and delivered into the general depot. This arrangement enables the approaches to the pier to be kept perfectly free, and does not interfere with any of the buildings of the works.

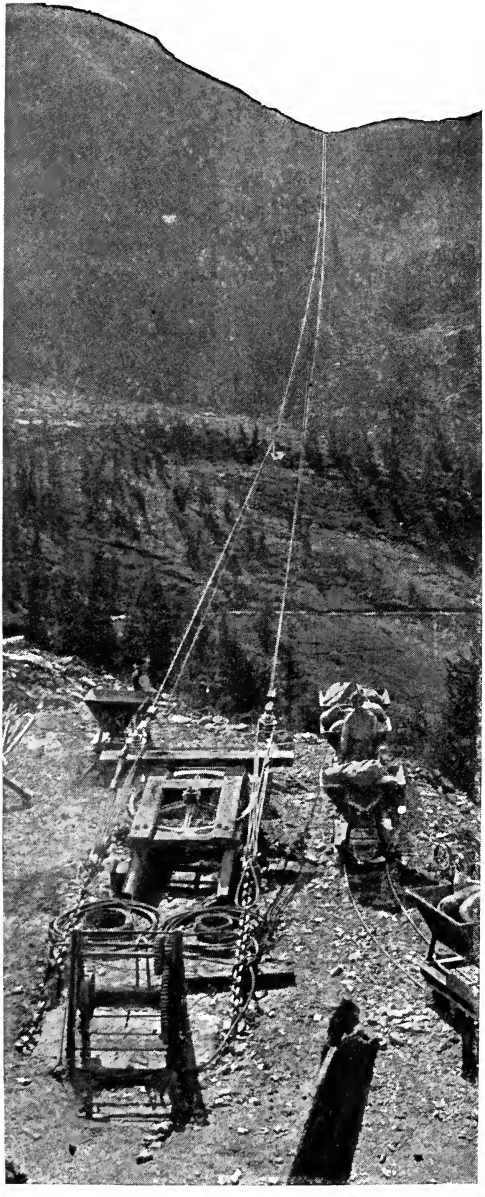
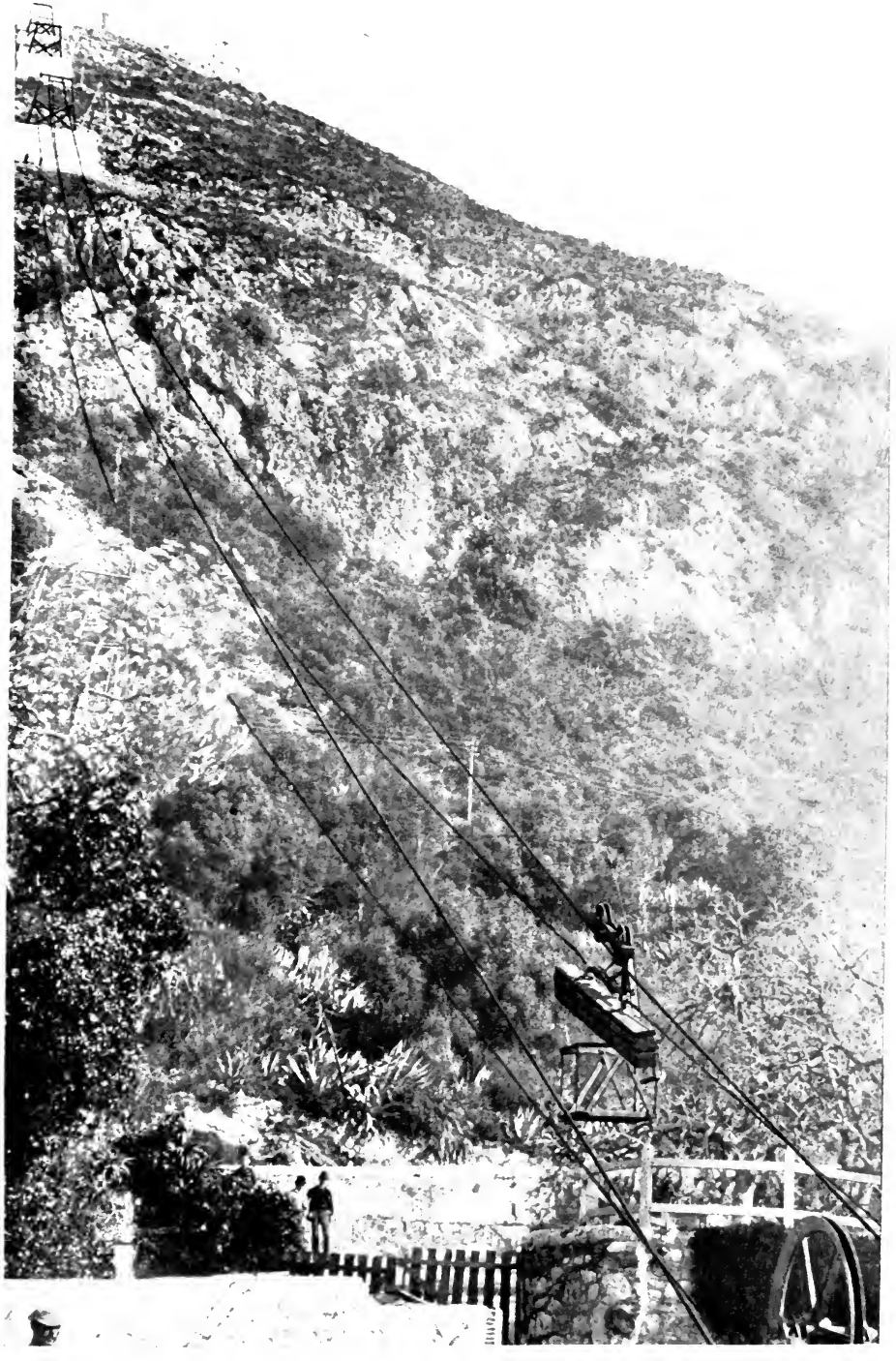


FIG. 9.—VIEW OF A ROPEWAY IN THE ALPS. SPAN 1,100 YARDS; LOAD CARRIED, 8 CWTS., SHOWING ARRANGEMENT OF TIGHTENING ROPES & ALSO GEAR.

(6) The use of ONE FIXED ROPE placed on an incline on which carriers, from which are suspended loads, are allowed to run down uncontrolled one at a time. This is generally called a "shoot." This system is of a simple nature, and used for the transport of undamageable goods. It consists of a light wire rope stretched between two points, the elevation of one being considerably above that of the other. On this, loads from 1 cwt to 4 cwt., hanging from a runner carrying one or two wheels, are allowed to run down uncontrolled. At the lower end, brushwood, or other convenient means, are provided to absorb the force produced by the running load when it arrives at the lower terminal. This can be considerably lessened by regulating the sag of the rope where the section of ground will admit, so as to reduce the speed of the runner with its load as it approaches the lower terminal. Such type of ropeway is largely used for the carriage of firewood, coffee, or other like materials. Spans can be made without support up to 7,000ft., and all that is required for fixing the rope is a good anchorage at the upper end, and another with a tightening gear at the lower end. Ropes for this purpose up to 3,500ft. spans are used, made in the form of a strand; above this, in order to obtain the necessary strength with a moderate size of wire, ropes are used consist-



VIEW OF THE LOWER END OF A ROPEWAY IN SPAIN, CONSTRUCTED FOR THE CARRIAGE OF BUILDING MATERIAL AND PASSENGERS.

ing of several strands formed each of several wires. The runners have wheels of small diameter, and are made as light as possible in order that, after 50 or 100 loads have been delivered, the empty ones may be carried up to the upper end for a further delivery of material.

The applications of this system are too numerous to recite; probably many hundreds of miles are in operation, and with a rope or strand of suitable material and strength, together with well-made runners, the carriage of such material as can be treated in the manner named above, is alike efficient economical, and speedy.

From the above descriptions the need of several systems to meet the varying needs of the situations where ropeways are erected must be clearly realised, and the large number of ropeways on each system which Messrs. Bullivant and Co. have erected from the author's designs, fully prove the efficiency of each system.

W. Larrington

ROPEWAYS AS A MEANS OF TRANSPORT.

By J. PEARCE ROE, M. I. & S. Inst.

THE employment of aerial ropeways as a means—and in many cases the best and most economical means—of transporting material under certain conditions has already been established, though the recognition of their merits, or at any rate their introduction in Great Britain, has been slow as compared with many other countries. This is doubtless due in a measure to the general proximity of quarries, industries and the like, to the numberless existing railways or their ramifications, and hence the more extended adoption of aerial ropeways in countries less well served in this respect. Another reason, to judge by the writer's experience, is a conservatism in adopting new appliances, as well as the difficulties not unfrequently imposed by landowners, local authorities and similar bodies with respect to way leaves and so forth, and it has several times occurred that while the would-be purchaser has been prepared to adopt an aerial ropeway plant, he has had to give up the scheme on account of extraneous opposition and the consequent expenses he would have had to incur in meeting it.

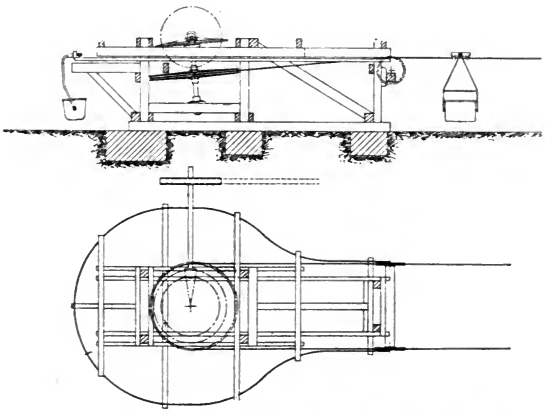


FIG. 1.—PLAN AND ELEVATION OF DRIVING STATION.

Incidentally it may be of interest to mention that in certain countries the utility and public benefit derived from ropeways is so well understood that special and very liberal laws relating to the necessary rights of way, etc., are in operation, so that the status of a ropeway as a means of transport is officially recognised in a manner that, it is almost needless to add, is unknown here.

In spite, however, of the facts just noted, there is unquestionably a very considerable, if not a large field for aerial ropeway transportation, and the writer, on behalf of the Ropeways Syndicate, Limited, has already constructed a good many lines in this country, while evidence is not lacking to show that greater interest is being taken in this mode of transport for minerals and other materials than formerly existed.

Aerial ropeways, it is almost needless to say, are not new, and although their origin appears to be somewhat

obscure, it may be said for all practical purposes that they seem to have taken workable form in the mind of Mr. Charles Hodgson, about the year 1868, when he both patented and commenced to operate wire tramways. In those days, however, they were crude things that naturally lent themselves to improvements, and the writer has been one of those who, having had an extensive connection with these appliances for the past 20 years, has introduced many important developments.

It may here be observed that ropeways can be broadly divided into two types—first, that in which a plain, endless rope both suspends the loads and moves them along; and second, that in which the loads are suspended from runners drawn along fixed rail cables by means of a separate traction rope. Each of these broad types differ again in detail according to the

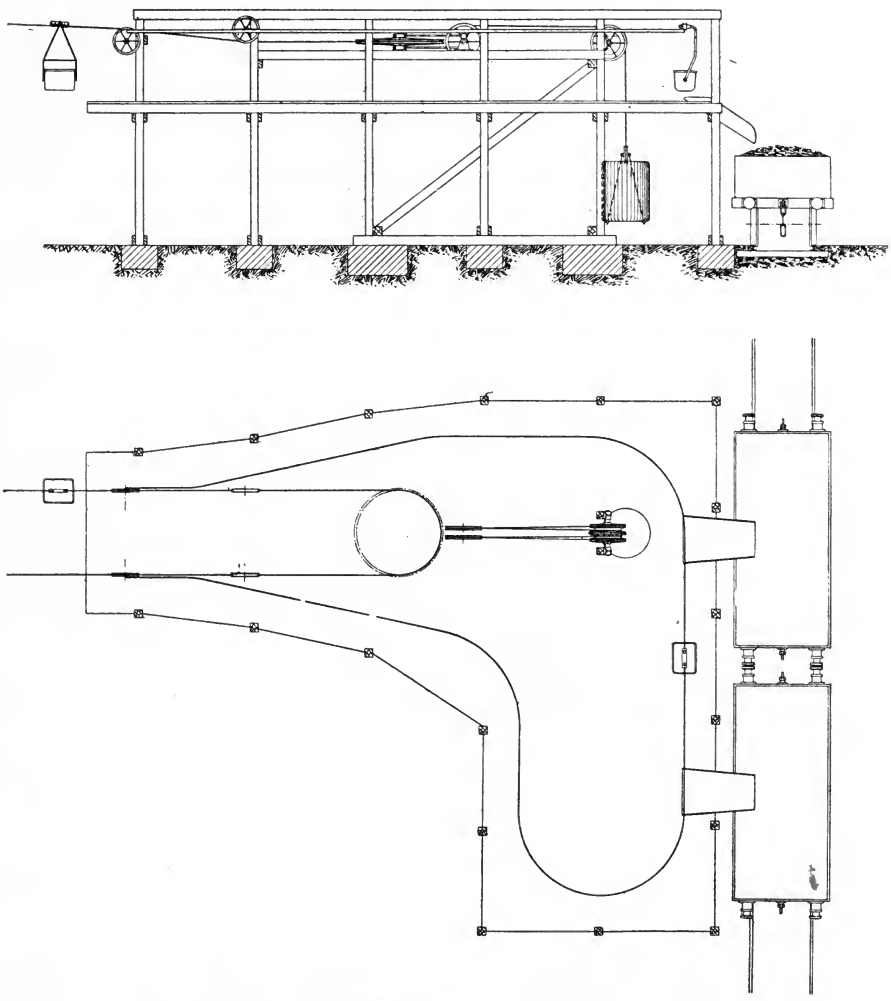


FIG. 2.—PLAN AND ELEVATION OF TENSION AND DISCHARGING STATION.

FIG. 3.—PART VIEW OF ROPEWAY LOOKING TOWARDS DISCHARGING STATION.

duty or kind of work to be performed. For instance, the design and mode of operation would be different where heavy individual loads are to be handled over short distances from what would be adopted for transporting over long distances regular quantities of such material as mineral that could readily be subdivided. These points and a variety

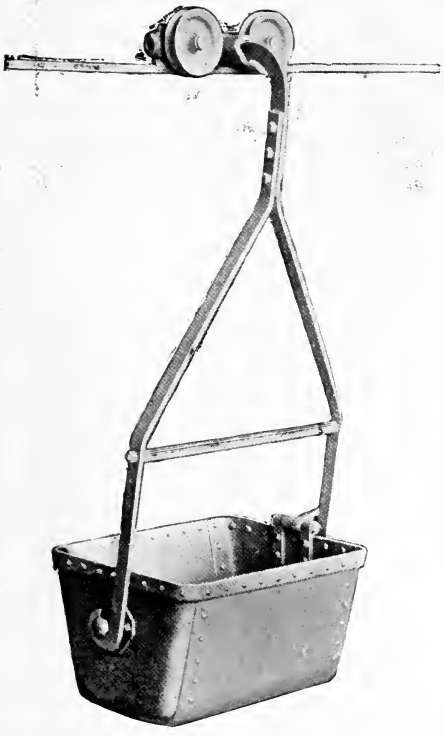


FIG. 4.—CARRIER AND MINERAL BUCKET.

of other factors, such as the nature of ground and so forth, determine the design of an aerial ropeway, and, as the conditions to be met are not alike in any two cases, it will readily be seen that careful consideration has to be devoted to each project upon its merits, if the best results are to be looked for.

From the foregoing observations it may be realised also that the purposes to which aerial ropeways can be put are so numerous that it would be beyond the scope of these remarks to treat the whole subject, and the writer, therefore, proposes referring more particularly to recent examples of single endless ropeways for the transportation of materials in the ordinary acceptation of the term, particularly as this is the most general use for which they are employed.

It may be observed that while the instances are numerous where aerial ropeways would compare favourably with light railways, even where no great difficulties occur in the construction of the latter, their merits become more particularly apparent where rough or mountainous ground has to be dealt with, and in such places the methods of the ropeway and railway engineer are fundamentally different, especially in the choice of ground, for while the one seeks easy grades by working round contour lines, and thus steers clear as far as possible of vertical irregularities, the other ignores this element within wide limits, and seeks rather to avoid curves in plan by striking as near as possible a bee line from point to point.

Then, again, with respect to power, intermediate grades being balanced, they are, broadly speaking, negligeable, the difference in altitude between terminals, or, in other words, the mean grade only, has to be taken into account in relation to power. In many cases, where the mean grade is in favour of the load, ropeways are self-acting, and in some instances develop a large amount of surplus energy.

An ideal ropeway should go straight from point to point, and the rope should be supported where the ground naturally lends itself to this without the introduction of high standards. In practice, however, this

FIG. 5.—PART VIEW OF 350 TON ROPEWAY IN SPAIN, SHOWING RUGGED GROUND AND LONG SPAN.

cannot always be absolutely carried into effect, but how nearly it has been realised in modern practice may be judged from some of the accompanying illustrations of various ropeways erected on the Roe and Bedlington system in different parts of the world.

In the early days of ropeways angles and high trestles were of frequent occurrence, for the purpose of avoiding heavy gradients and spans, but with the improvements now at command they are, or should be, the exception.

FIG. 6.—VIEW SHOWING ROUGH GROUND AND PORTION OF LONG SPAN.

An example of what the Roe and Bedlington improvements suddenly effected may be cited. In the first line that the writer designed and erected in which these were partially introduced, the valleys were spanned direct without intermediate supports, and the number of these was only nineteen in a ropeway having a daily capacity of 250 tons, and a length of 2,750 yards, with intermediate grades of 1:2¼.

It happened that in the same district a ropeway of the same length and capacity had been previously erected where the number of trestles amounted to 83, and many of these exceeded 100ft. in height. To put the matter in another way, the trestles, if placed one on top of the other, would in one case have reached an altitude of about 450ft., and in the other about 3,600ft., both installations being of about the same length and daily capacity.

The self-resistance or friction of ropeways, which, by the way, is a fair measure of wear and tear, varies very considerably, and is largely dependent upon care and suitability of design, proper distribution of strains, and class of material employed. For instance, the writer has known lines for 300 tons that have required power to drive them, despite the fact that there has been a mean grade of fully 1:6 in favour of the load; whereas, on the other hand, in a recent example within the writer's practice, surplus power has been obtained from a ropeway having a mean grade in favour of

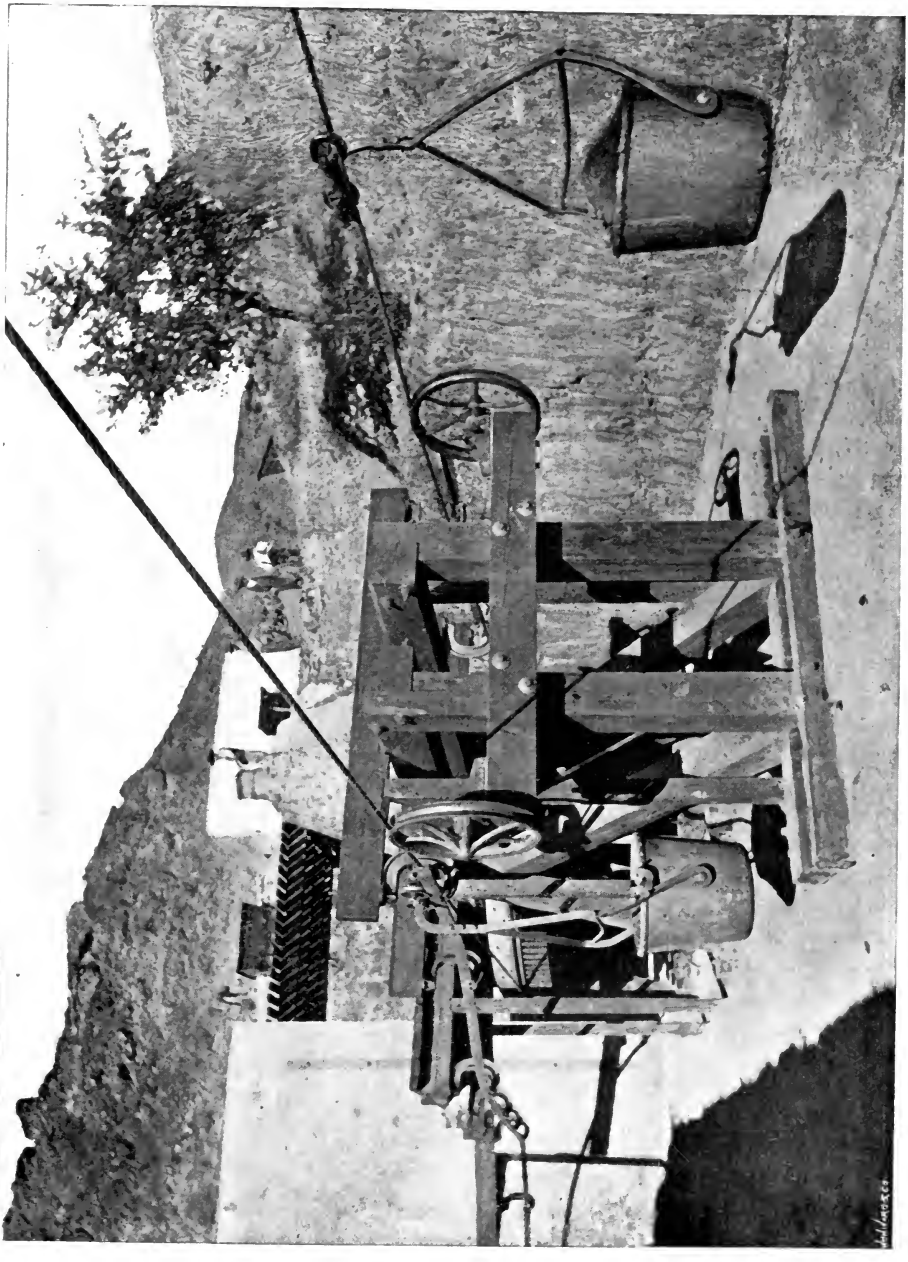


FIG. 7. LOADING STATION AND BUNKER.

the load of only 1:23. It is proper to say in this connection that the mechanical efficiency of a ropeway having a considerable capacity is somewhat higher than for small quantities, and the line just referred to was a 350 tons per day installation.

When the aptitude of a ropeway for dealing with rough country as it comes is realised, its advantages as a means of transport become manifest where the quantities are within range of its capacity. This is brought home in a striking manner by noting the difference in altitude between terminals in some of the ropeways that the writer has designed and erected, and also comparing the length of the ropeways and the length of rail track that would be required at an average grade of 1:40 to deal with the same difference of altitude. Thus in one instance the ropeway length is only 1,630 metres with a difference of altitude of 645 metres, which would require with a railway a length of 15 miles, graded at 1:40. In another case the ropeway length is 2,700 metres, and the difference of altitude between terminals of 403 metres, equal to nine miles of rail at 1:40 grade. Analysis of another ropeway, where length is 4,200 metres, shows that 13 miles of rail at 1:40 would be needed for the altitude.

With such figures as the above in the mind's eye, it at once also becomes apparent that not only is the capital outlay for ropeway plant in many cases much less than that required for a railway, but the cost of transport from point to point is also much smaller, and hence from all aspects the ropeway in numerous instances is the best and most economical mode of transit that has yet been devised—a dictum that holds good even when taking into full

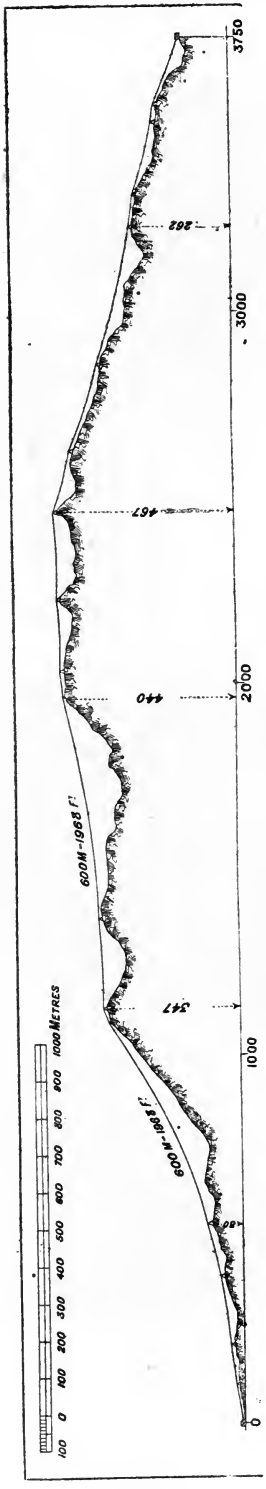


FIG. 8.—SECTIONAL PROFILE, SHOWING STEEP GRADES AND LONG SPANS OVER VERY MOUNTAINOUS GROUND.

A remarkable example of the author's practice in covering a long distance with few and low supports.

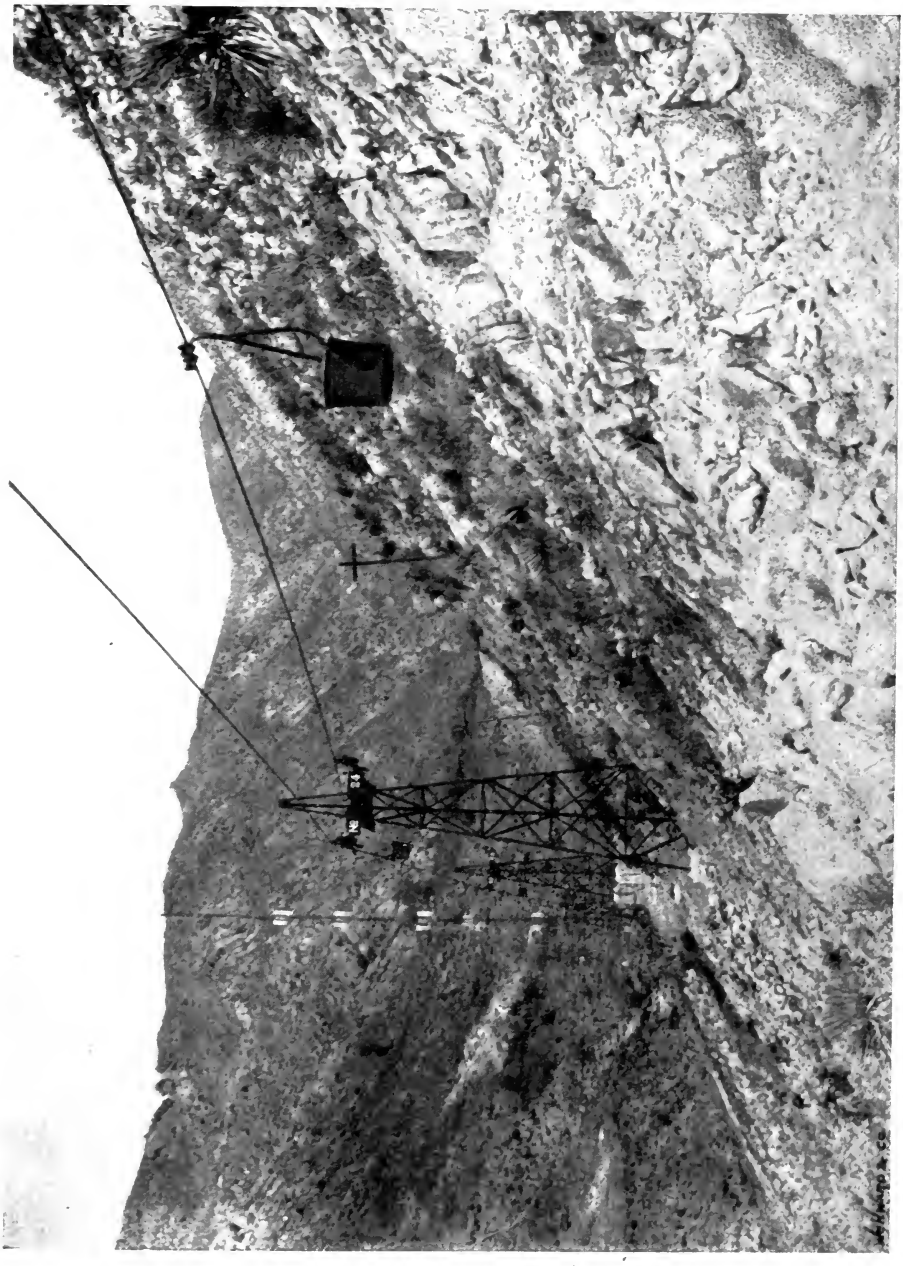


FIG. 9. VIEW SHOWING VERY STEEP INCLINE WORKING WITH ROE CLIPS.

account that the cost of transit per unit of length is in some circumstances higher by rope than rail.

In well designed and constructed installations of modern date, the cost of transport per ton per mile is, however, remarkably low, although it necessarily varies a good deal according to the conditions to be met, quantities to be handled, etc. On some of the Roe and Bedlington lines under observation rope costs—which represent the largest item under the head of wear and tear—have been reduced to something below one-third of a penny per ton per mile.

The illustrations, Figs. 3, 5, 6, 7, show different portions of a ropeway, having a capacity of 350 tons per day, for the transport of iron ore from mines in the hills to a railway junction in the south of Spain, and convey a fair idea of the ready manner in which ground of a rugged and irregular nature is dealt with. It will be seen from the photographs to what extent prominent parts of the ground are taken advantage of for supporting the ropes, and the way valleys are spanned so as to avoid, as far as possible, high trestles. The average height of these is only 20ft., and average distance apart 110 yards, although the spacing is of course really irregular, and there are spans of considerable length, one being over 1,200ft.

The upper terminal station, and the manner in which the carriers take on to and leave the rope, so as to permit of their being run on shunt rails

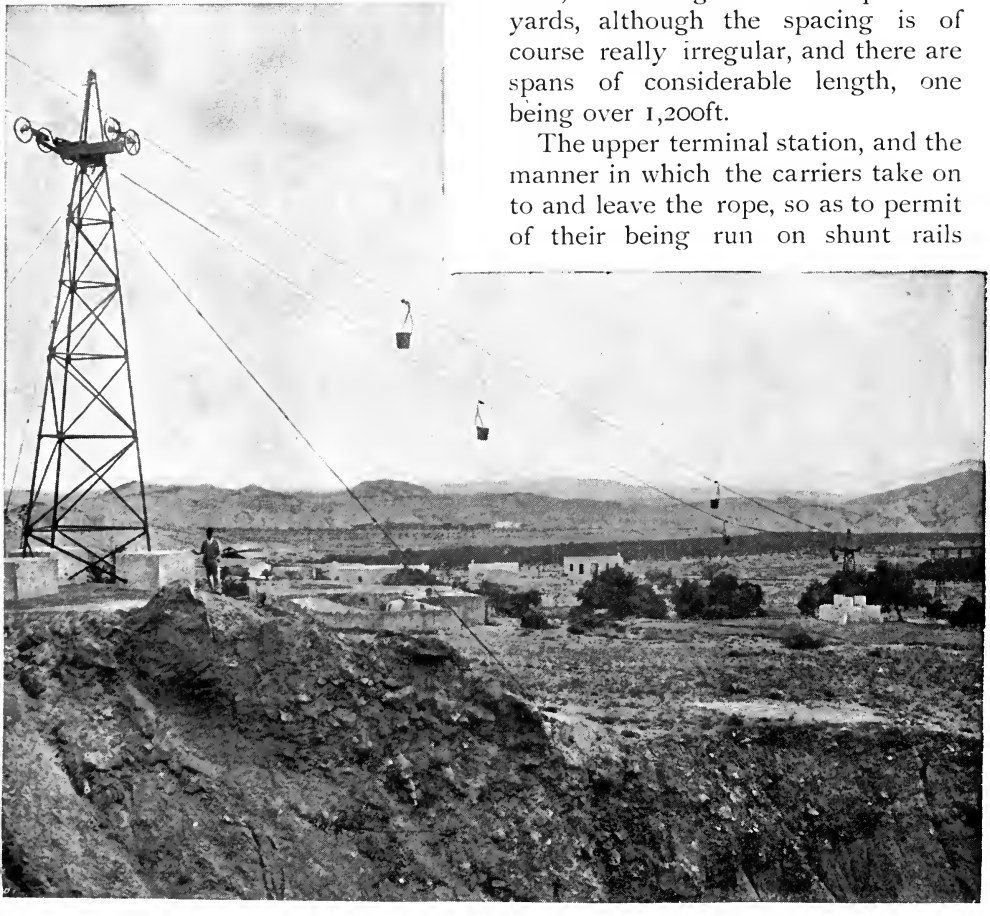


FIG. 15.—GENERAL VIEW OF PORTION OF ROPEWAY, SHOWING 35-FT. TRESTLE.

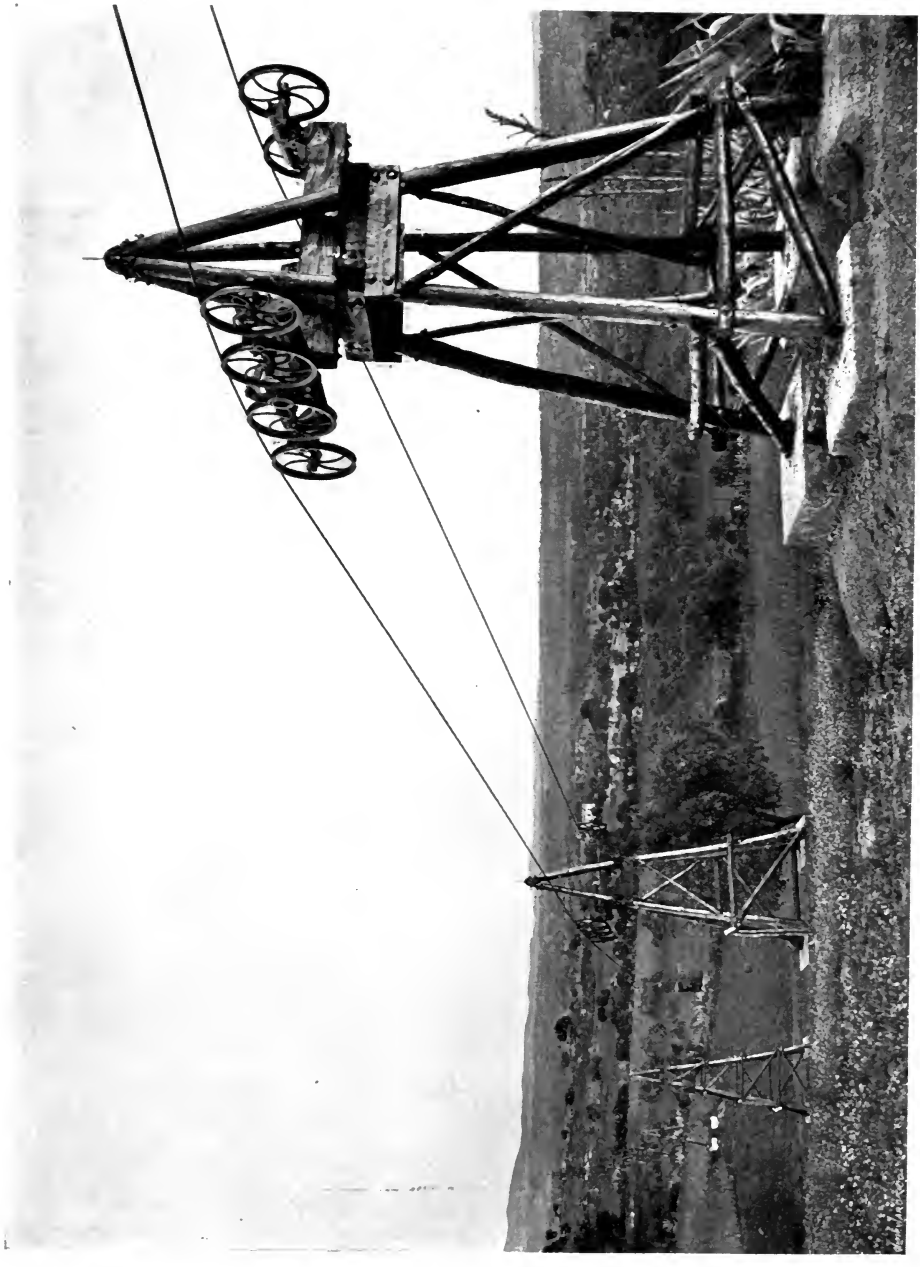


FIG. 11.—VIEW OF ROUGH TIMBER TRESTLE AND EASY GROUND.

round a bin or bunker for loading is shown in illustration, Fig. 7; and in Fig. 10 is seen the highest trestle on this line, with the discharging station in the background, where provision is made for stocking some 8,000 tons of mineral. This line is self-acting, and an automatic regulator is fitted to govern the speed.

The illustration, Fig. 9, has reference to a 300-ton daily capacity line having a length of 4,500 yards, which is also self-acting and is worked in one section. It is employed for the transport from mines to smelters of argentiferous ore in Mexico. The route in this instance is over exceptionally rough and mountainous ground, and some idea of this and the onerous work of erecting such an installation may be gathered from the photographs. It may be mentioned, too, that all the material for construction had to be conveyed by bullock and pack mule for some 100 miles over trackless, mountainous ground.

The ropeway, a part of which is illustrated in Fig. 11, is over easy ground, forming a contrast with some of the examples already referred to, and rough local Spanish timber is employed for the trestles, which, from an engineer's point of view, do not compare in appearance with wrought iron structures.

The illustration, Fig. 4, shows in some detail an ordinary form of mineral skip and hanger attached to the carrier, which is shown resting upon a rope. The whole is constructed of mild steel and malleable iron.

Apart from the photos the writer thinks the profile illustrated in Fig. 8, will be of interest, as showing probably the roughest piece of ground ever dealt with even by an aerial ropeway. This is laid out naturally, the vertical and horizontal scales being the same. It refers to a ropeway having a capacity of about 60 tons in one direction and 30 tons in the other, per day. It will be observed that in this case there are only 17 supports for the whole distance, which measures some 4,000 yards, and each support is placed on the top of the hills, which causes them to be all low structures, while long spans are worked from point to point, two of these clearing distances of nearly 2,000ft. without supports. The rope passes over a ridge 1,520ft. at its highest point above the discharging station. In this line, too, an altitude is attained of 1,130ft. in the remarkably short distance of some 1,200 yards.

The writer has more than once had it urged that an aerial ropeway interferes with a landscape, and in one English case a scheme had to be abandoned on this account. To what extent this is the case may be left to more impartial judges than one professionally engaged in ropeway construction, but a glance at the illustration on the opposite page will dissipate the notion that there is anything unsightly in either the structural or running work of an aerial ropeway when well designed.

The present remarks have purposely been confined to that class of ropeway employed for the continuous transport of material over considerable distances, but it must not be supposed that this by any means exhausts the uses to which aerial ropes can be put by introducing special features for the work to be performed, and in this connection it will perhaps not be out of place to indicate in a general manner their adaptability to such purposes as the following :—The conveyance of bales and other material from point to point or between buildings, over roofs and yards in factories.

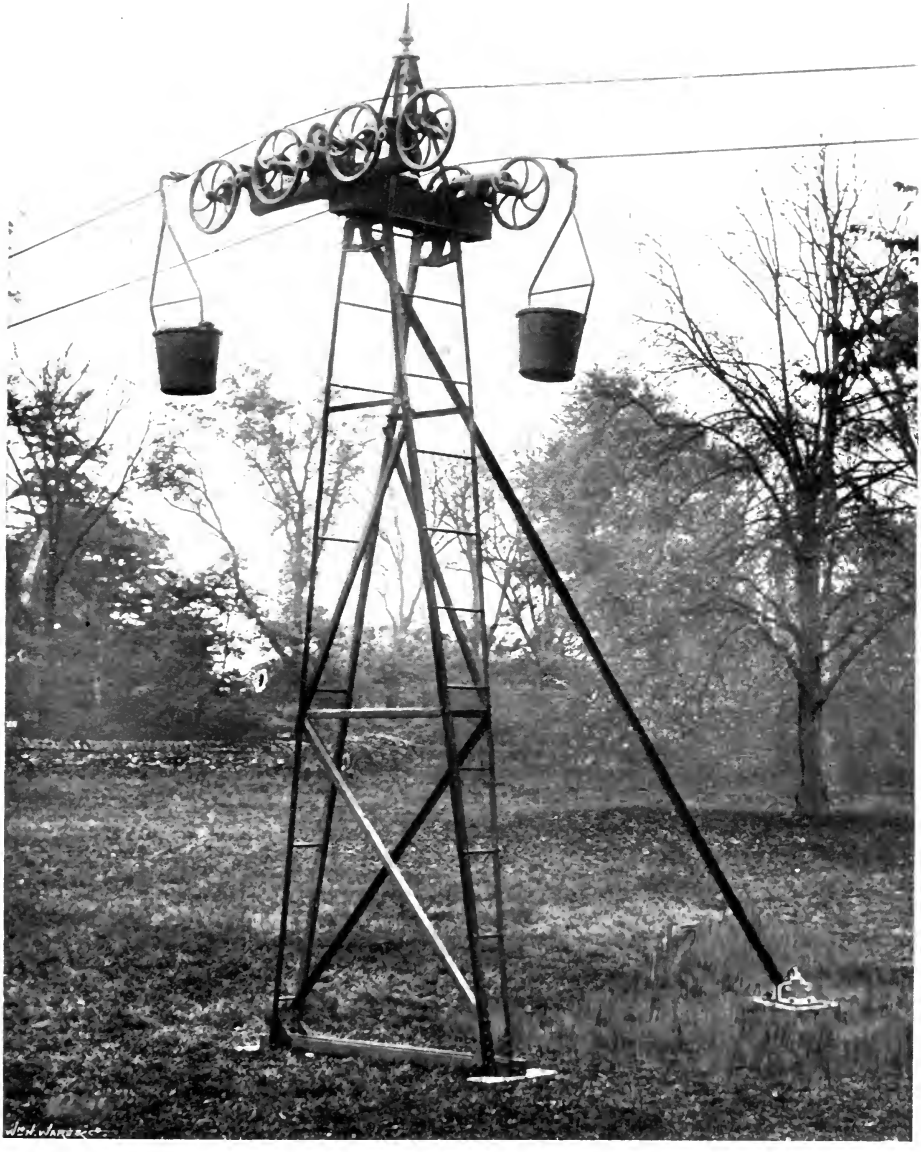


FIG. 12.—VIEW OF LIGHT STEEL TRESTLE, SHOWING BALANCE SHEAVE GROUPING FOR DISTRIBUTING ROPE PRESSURE.

For making direct and short connection across ravines for the conveyance of persons and merchandise by which circuitous and long mule or cart tracks would be avoided by the introduction of a single span, and the writer has also proved their usefulness and economy for handling constructive material up precipitous ground from lower lying and more get-at-able points to sites at an altitude where the work had to be erected. Other instances of their utility may be found in connecting lines of railway at opposite banks of rivers where bridge building would be unduly costly or difficult, and lighterage, on account of floods, shoals, etc., impossible. In an example of this kind plant was constructed by the writer to pick up wagons with their loads, traverse and put them on track at the other side and *vice versa.*

Another class of ropeway known as suspended cableways is also exceedingly useful for bridge and dam construction, as well as in connection with certain kinds of quarry work and the like.

Thus it will be seen that with the variety of purposes to which they can be applied, it can hardly be doubted that ropeways have a great and increasing future before them, and that as a means of transport alone the field for their employment is very extensive, and will become wider as experience of their working displaces the want of knowledge and prejudice that have to a considerable extent existed. Greater familiarity would also tend to save the ropeway engineer from the many very curious enquiries that emanate from would-be users with hazy ideas as to the legitimate uses of this mode of carrying material. This will be understood when reference is made to an enquiry for transporting waiters and their tea-trays, etc., between pavilions in connection with a refreshment business, and others of a similar kind, coupled with suggestions that the constructor should take payment in gate money. An enquirer also occasionally specifies that trees somewhere or anywhere near the route are to be made use of for supporting the ropes. There was a slight epidemic of this sort of thing after the publication of an illustrated reference to ropeways in a popular magazine, which indicated also that there was a prevalent idea that ropeways could be supplied at popular prices, something in advance of a clothes line. Needless to say, they cannot be, and there is no immediate prospect of any such happy development as would meet expectations of the kind. Such enquiries are, of course, harmless, and, frequently, comical, but it occasionally happens that injury is done to the reputation of ropeways by the class of gentleman commonly described as "a bit of an engineer," and who goes lightheartedly to work in the belief that he is fully equipped with the necessary knowledge to tackle a ropeway problem, and ends in becoming a sadder and wiser man, who has incidentally damaged a good thing having a large and useful future that would be the better for intelligent encouragement.

"OTTO" ROPEWAYS.

By R. E. COMMANS, M. Inst. C.E.

I SHOULD like to preface the remarks I have to make by saying that, although I consider the original single rope system of aerial ropeways very suitable for short lines with easy gradients and small carrying capacity, I am satisfied that, for anything like a permanent installation, where large quantities have to be carried over rough country, the double rope, or "Otto" system is the best. For this reason, therefore, I propose to confine myself to a description of this system.

It is now a good many years since this system was first introduced, and to-day there are over 900 of these "Otto" lines at work in different parts of the world.

The advantages of aerial transport are by no means appreciated as they ought to be, and the more these are made known, the better for both makers and ought-to-be users.

By the single rope, or "Hodgson" system, one endless running rope is employed, fulfilling the dual functions of carrying and hauling. The characteristic of the double rope, or "Otto" system on the other hand, is the employment of two ropes—a heavy fixed rope of large section for carrying, and a light running rope for hauling the buckets along the said carrying rope.

A single rope line, as far as first cost is concerned, is therefore evidently cheaper than a double rope line, and for this reason, in certain cases, it might be given the preference. Cheap is perhaps a wrong term to use; less expensive would be possibly more correct, for if there is one thing more than another to which the old saying "cheap and nasty" applies, it certainly is an aerial ropeway. Like a chain, the soundness and reliability of a ropeway are entirely dependent on the strength of its weakest link, so that, no matter how good the ropes may be, if any detail in the driving gear, or more especially

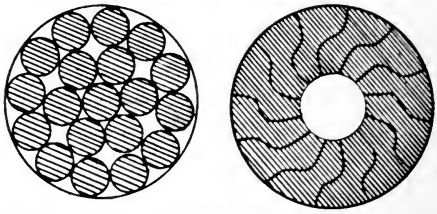


FIG. 1.—ORDINARY SPIRAL ROPE AND NEW PATENT LOCK COIL ROPE.

in the grips—by which the buckets or carriers are attached to the rope—should fail, the whole line may come to a standstill, resulting in endless worry, annoyance, and expense.

It might be well here to mention that anyone is at liberty to use double ropes. It is to the numerous *details* which go to make up a complete ropeway installation that the "Otto" patents apply, details which have been arrived at only after years of practical experience gained in the erection and running of these lines.

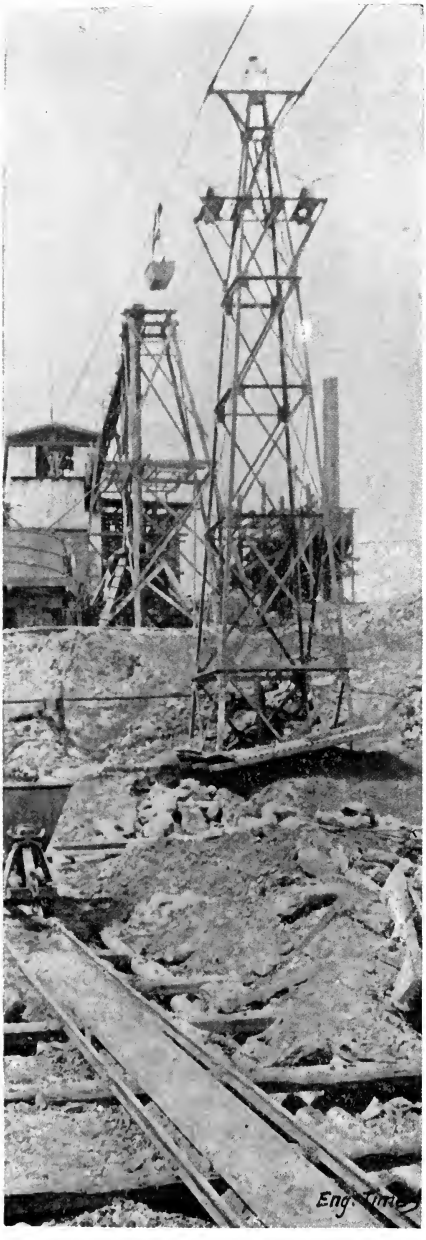


FIG. 2.—ROPEWAY AT LAKE VIEW GOLD MINE.

In an article like the present it would be impossible, and out of place to fully describe these details and the many improvements to which the great success of this system of aerial transport is entirely due.

To those who have had any experience with wire ropes, it will be evident that a quick running hauling rope, which has to work round grooved pulleys, should be as light and flexible as possible, in other words, should be built up of numerous strands of small wires. If the same rope be required to both haul and carry the load, it is further evident that it would have to be of larger section than if it had the hauling alone to do. This increase of the size of the rope means more weight to drive, and consequent loss of power, and greater wear and tear. Where, therefore, heavy loads have to be carried, large spans to be crossed, and steep gradients surmounted, it is highly desirable to employ fixed or rail ropes to carry the load, and a light rope to do the hauling.

Numerous forms of carrying rope have been tried, and in the earlier days even iron rods were used to carry the buckets. Two sections of carrying rope employed in the construction of the "Otto" lines are shown in the illustrations. Fig. 1. The ordinary spiral rope composed of stout round steel wires and the patent Otto "Simplex" lock-coil rope. Where first cost is not of primary importance, the latter rope is strongly to be recommended. This simplex lock-coil rope is a comparatively recent improvement, and has proved an immense success wherever it has been employed, and is in fact an ideal section for this special purpose. These simplex ropes were used for the ropeway supplied by me to the now famous Lake View Gold Mining Company in Western Australia, a view of which is shown in Fig. 2.

This ropeway is employed to transport ore from bins erected alongside

the shaft to the top of the 50-head stamp mill, situated some distance off on the hillside. The ore, as raised from the mine, is dumped over a grizley, or screen, the fines falling through direct into the bins below. The big pieces pass to a Gates Rock Breaker to be further crushed before falling into the bins, from which through half-a-dozen shoots, the ore is rapidly delivered to the ropeway buckets. The object of placing the mill on the hillside was to secure the advantage of natural gravitation for dealing with the slimes and tailings, the cyanide house being situated on the slope of the hill about halfway between the main shaft and the battery. The plant works admirably, and has conveyed the ore without interruption to the mill ever since the ropeway was started.

It is surprising what vague notions many people have with regard to ropeways. They seem to think nothing could be simpler than to run a rope across country on top of sundry poles. When they are informed that it is not possible to work in and out and generally round about, and that the height of each support, the distribution of the loads, etc., all require to be most carefully calculated, they appear astonished, and slowly begin to realise why a ropeway cannot be sold at so much per ton.

When entertaining the idea of employing a ropeway, the following points should be borne in mind :—

The end stations, wherever possible, should be so chosen that the ropeway connecting them will be in a straight line, and also so arranged that the loading and unloading may be performed with the least amount of handling. If the ropeway cannot be carried in a straight line from one station to the other, one or more intermediate, or angle stations would be required. These, however, increase the first cost of the line, and also add to the working expenses of the same.

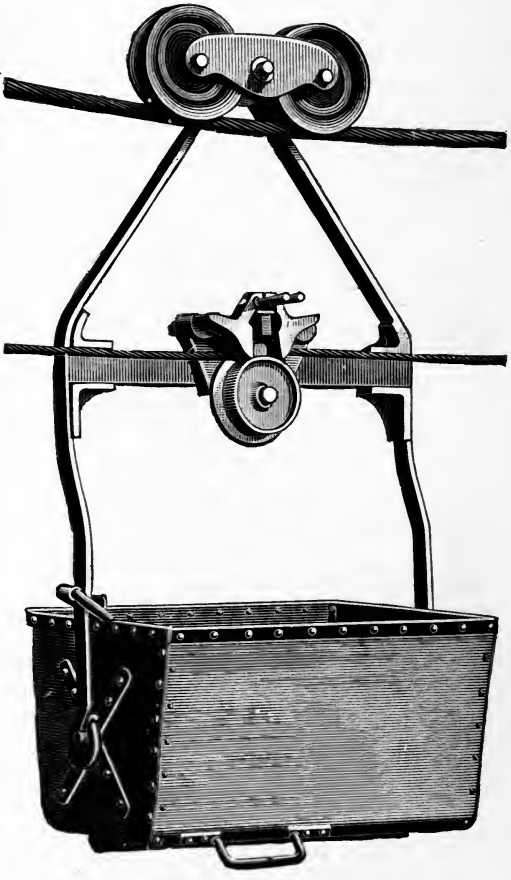


FIG. 3—BUCKET USED ON THE "OTTO" ROPEWAYS.

The distance between any two stations, even over favourable ground, should not exceed 3½ miles. Wherever there are steep gradients, especially where large quantities have to be carried, the stations should be nearer than this to one another in order to avoid too great a strain on the hauling rope.

If it be necessary to divide a line into sections for any of the above reasons, the positions of the intermediate stations can often be so chosen as to secure a more evenly graded route for the ropeway, than if it were carried in a straight line between the terminal stations.

The design of *carrier* depends on the material or class of goods it is intended to transport over the line. The bucket carrier shown in Fig. 3 is very largely used and is suitable for coal, ore, clay, sand, and such like material. The buckets are suspended slightly below the centre of gravity, which permits of their being easily tipped and emptied of their contents.

FIG. 4.—ILLUSTRATION OF AN "OTTO" ROPEWAY SHOWING LOADED BUCKETS ON ONE SIDE AND EMPTIES RETURNING ON THE OTHER.

Fig. 4 gives a very good idea of the general arrangement of an "Otto" ropeway, and shows the loaded buckets being hauled along on the one carrying rope, and the empties returning to the loading station on the other. For the transport of logs, sacks, barrels, boxes, etc., sling carriers are handier than the bucket ones, as they permit of the loads being very quickly despatched and discharged.

The *supports* can be made either of wood or iron. Fig. 5 shows a good example of a wooden support of an "Otto" line at work at the Progress Mines in New Zealand, employed for the transport of gold quartz. The timber for these supports was cut in the adjoining forest. This line, which is some 7,000ft. long, has at its lower end a span of 1,900ft., or nearly two and a half times the width of the Thames at London Bridge. Where timber is scarce, or the white ant in evidence, iron supports should be used. Such supports are shown in Fig. 2 which is a view of the Lake View Company's ropeway above referred to.

Where large quantities of ore, or similar material, have to be transported, it is highly desirable to so construct the *loading stations* that the

FIG. 5. EXAMPLE OF A WOODEN SUPPORT OF AN "OTTO" LINE IN NEW ZEALAND.

buckets can be filled automatically from spouts connected with bins, or hoppers overhead. In this way no time is lost, and the carriers can be regularly and rapidly forwarded as soon as they are filled.

The *unloading stations* should also be designed so as to reduce as far as possible unnecessary handling of the material. Fig. 6 shows a fairly typical unloading station, with bins of large capacity arranged alongside

very generally employed. These can be fixed at either the loading or unloading stations as most convenient.

The *grips* for attaching the carriers to the hauling rope are automatically thrown into gear, and released at the loading and unloading stations. These grips are the most vital part about a ropeway; there must be no uncertainty about their action, and no matter what the climate or weather may be, one must feel quite sure that

FIG. 6.—UNLOADING STATION AT MOUNT LYELL MINE IN TASMANIA.

the railway for automatically loading up the railway wagons with ore, or whatever is brought down by the ropeway. This unloading station is of an "Otto" line just completed for the Mount Lyell Mining and Railway Company in Tasmania.

Where it is desirable to check the weight of the material carried over a line, weighing machines (see Fig. 7) which automatically record the weight and number of each load, are now

when once a carrier has started on its journey it will arrive at the end of it without a hitch of any kind. As a proof of the reliability of the "Otto" grip under most trying circumstances, I would mention the case of a ropeway in Norway constructed for the Bede Metal Company, and used for the transport of copper ore. In the winter the cold being most intense, it often happens, after this ropeway has been standing all night, that

when the line is started in the morning, the ropes and buckets are thickly covered with ice and snow, but in no single instance have the grips been known to fail. Fig. 8 shows the loading station of this line taken when snow was on the ground.

Heat also has its drawbacks, and must be allowed for in the design of these ropeways. I well remember a rather amusing incident that was told me by an engineering friend of mine, who some years ago was present at the starting of a single rope line he had designed for a mine in the tropics. The line was to work by gravity, the descending loaded buckets hauling up the empty ones. When everything was ready, and the signal given to start, the rope refused to budge. My friend was at his wits' end to account for this, as he felt sure his calculations were right although the margin of surplus power was small, and, with the patience and long-suffering common to his class, meekly submitted to the rather tropical abuse of the mine manager, and chaff of his staff. All of a sudden, to the surprise of everybody, the line commenced to move of its own accord. The laugh was now on the side of the engineer, who, in a moment, grasped the situation: the rope, due to the mid-day heat, had become elongated, the tension reduced, and the friction, which had been too great, overcome. On investigation, it was found that an all too conscientious fitter had rigidly fixed the tension gear, and as soon as

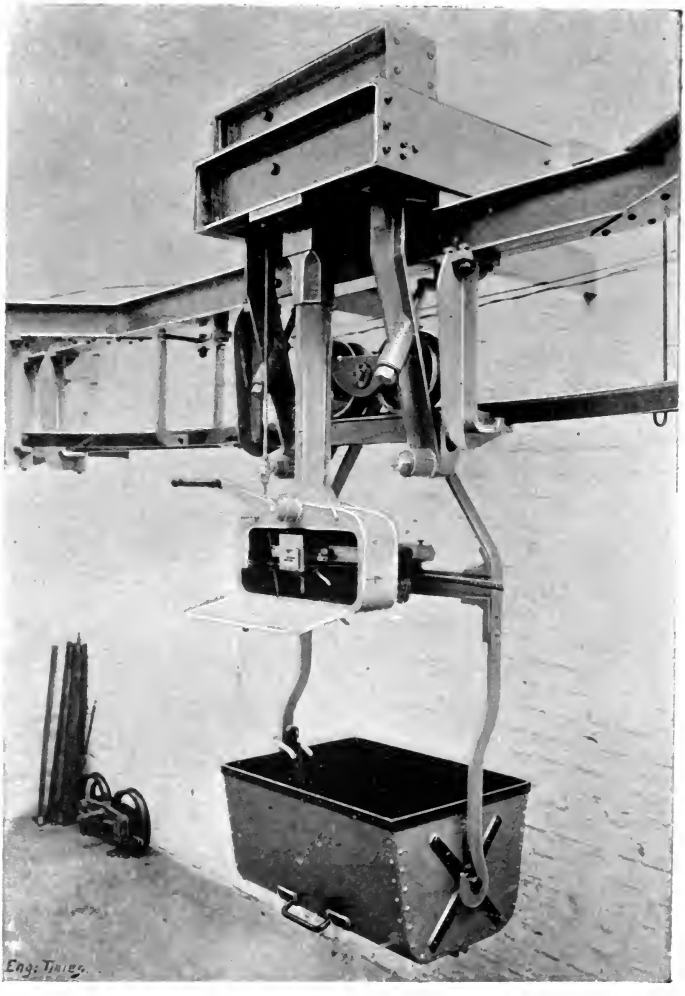


FIG. 7.—AN AUTOMATICALLY RECORDING WEIGHING MACHINE.

this was released, the line worked away beautifully.

Ropeways have been little adopted in this country, due in a great measure to the difficulty experienced in almost every instance of obtaining the necessary way leaves. Some landowners object, no doubt, conscientiously, and are prejudiced against this system of transport, under the impression

FIG. 8.—LOADING STATION IN NORWAY.

that the line will interfere with their crops, or that the buckets may discharge their contents on them, or on their cattle. The majority, however, I fear, are not so conscientious in their objections, but are swayed by other motives, and rather look upon a ropeway in much the same light as they would upon a railway, and appear to think that, as a matter of principle, it is their duty to impose upon the unfortunate company or individual who is desirous of taking a ropeway over their land. Owners of bog and moor land, which, before the idea of a ropeway was mooted, would have been glad to find a purchaser at almost any price, suddenly discover this same land to be most eligible for building, and ask a prohibitory amount for a right of way accordingly. I could cite a number of instances where ropeways, which would have been most beneficial to a district, have had to be abandoned owing to it being impossible to come to terms with one or other of the owners of the land over which the line would have had to pass. As already stated, ropeways cannot be worked round curves, and, therefore, one dog-in-the-manger proprietor, by

objecting to grant a right of way, may render the carrying out of a scheme on a workable basis impossible.

It is high time that our County or Parish Councils, as on the Continent, had powers, where they see it is desirable in the interests of the community at large, to compel ignorant or unprincipled proprietors to submit their claims to arbitration, or to accept a fair compensation for any

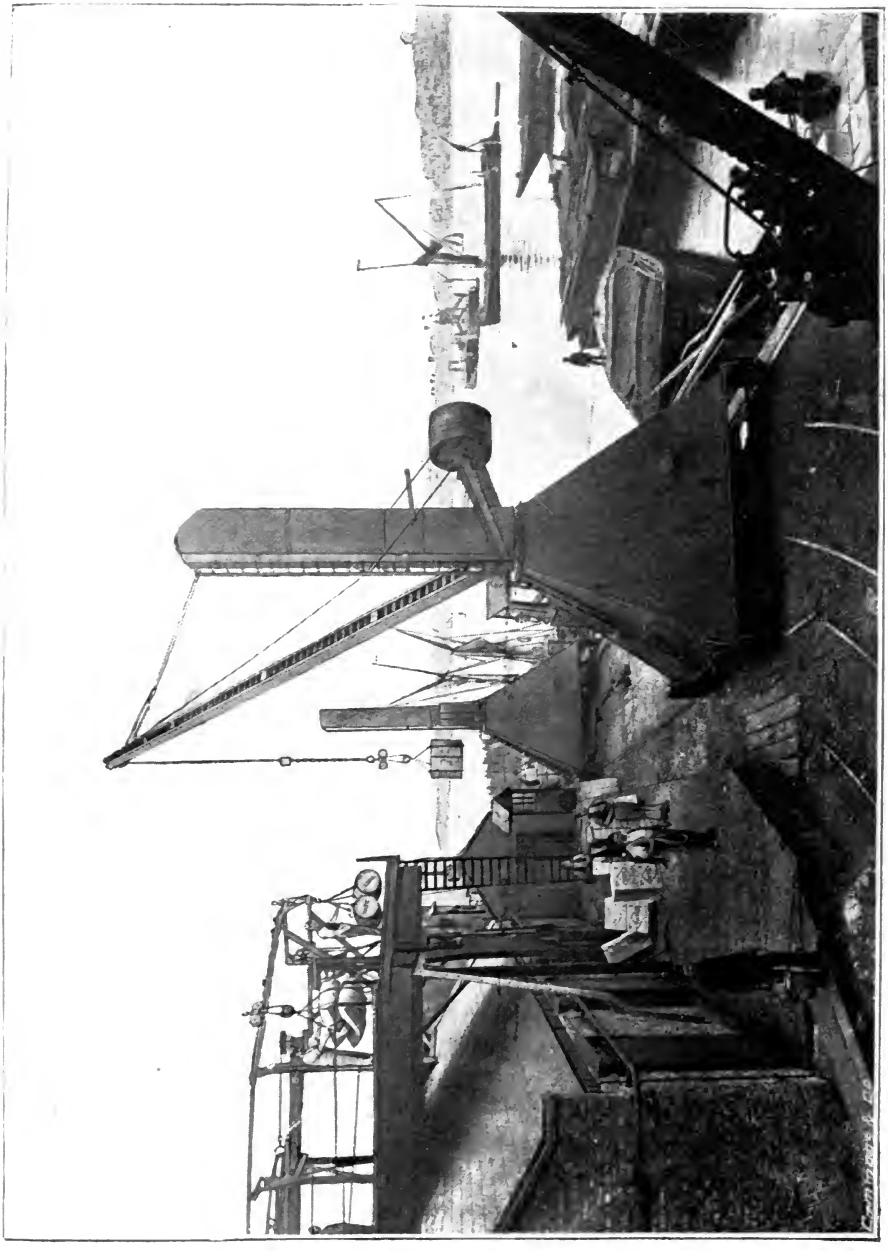


FIG. 9.—ROPEWAY EMPLOYED FOR THE TRANSPORT OF BOXES, ETC.

slight inconvenience they might be put to.

Ropeways in no way interfere with the cultivation and natural drainage of the land like a railway, and the graceful curves of the ropes and general airiness of the whole structure, are a pleasing addition to any landscape.

The carrying capacities of these lines may be anything from 50 to 500 tons and more per day of ten hours. Whenever the quantity carried exceeds 800 tons it is advisable to build a double line. On the well-known Garrucha Ropeway, in the Sierra de Bedar district, in the South of Spain, although this is only a single line, as much as 800 tons of iron ore have been carried per day of sixteen hours. This line is $9\frac{3}{4}$ miles long. The accompanying illustration, Fig. 10, shows the large span, over 900ft. wide, at Villa Reforma. This line was constructed and run for a number of years by Mr. J. Pohlig of Cologne, to whose untiring energy and skill the immense development of the "Otto" system on the Continent is mainly due. He has constructed still longer lines, $12\frac{1}{2}$ and

FIG. 10.—A SPAN OF OVER 900 FEET

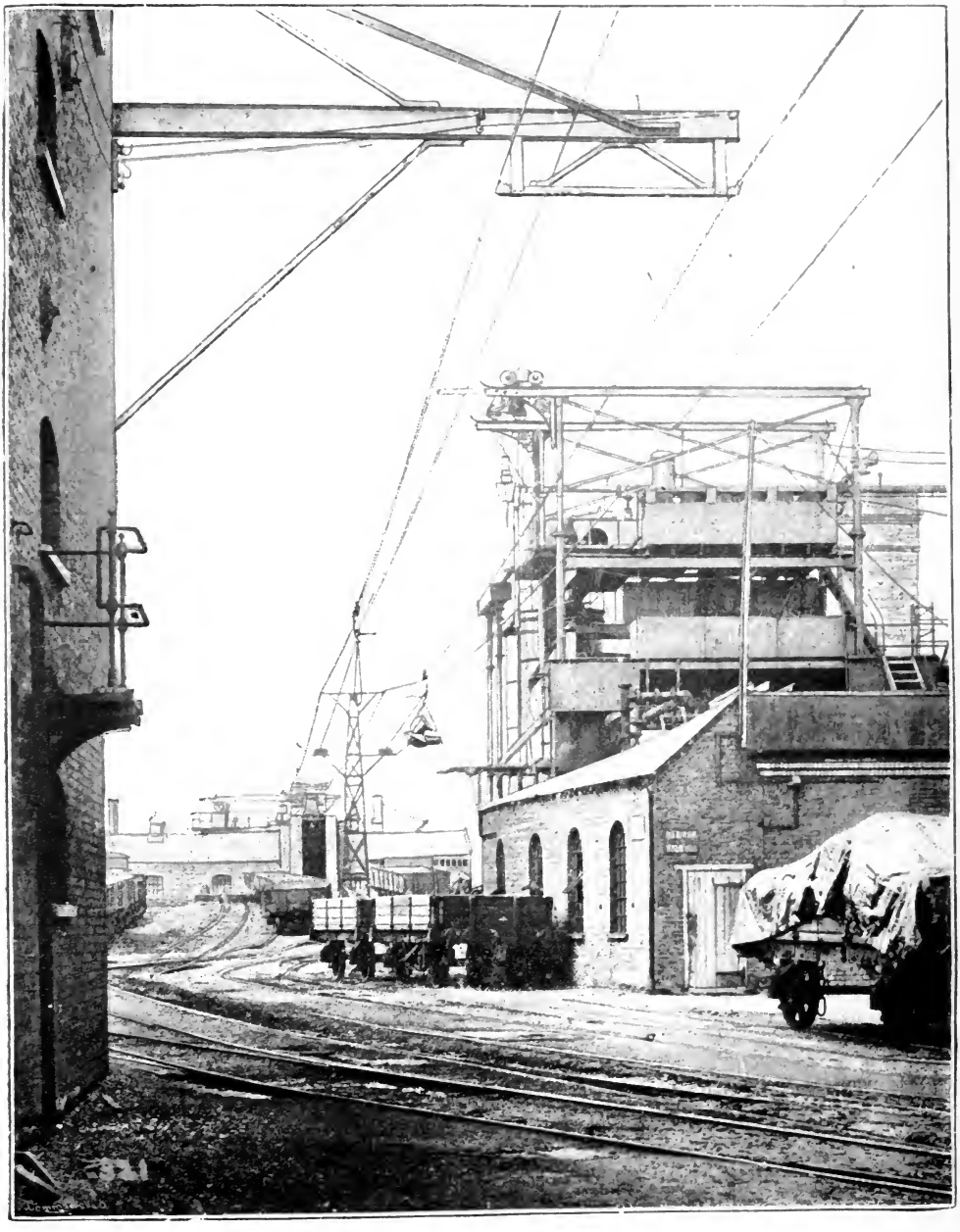


FIG. 11.

19 miles respectively, in Hungary, and only quite recently has completed the survey of a line for the transport of general merchandise over mountainous country for a distance of 30 miles.

Although ropeways are more especially used in connection with mining, they may also be employed with great advantage to industrial purposes, and, as a case in point, I would refer to Figs. 9 & 11, of a short line I supplied some years ago to Messrs. Henry Tate and Sons for the transport of sacks, barrels and their well-known boxes of cube sugar, at their factory at Silvertown. By means of this ropeway, they were enabled to carry goods from a warehouse over a yard to the wharf side without in any way interfering with the shunting of the railway trucks below. In this case the sling carriers above referred to were used, and have proved a great success.

I also supplied a similar ropeway to Messrs. Lever Bros. for the transport of alkali, etc., from lighters into their works at Port Sunlight.

With the improvements constantly being made in the material and design of the ropes and various parts constituting a ropeway, these lines are bound to come more and more into general use, and it is to be much regretted that their introduction into this country has been so handicapped, as explained above, by the difficulty of obtaining the necessary way leaves.

R. E. Commans.

SECTIONAL AERIAL WIRE ROPEWAYS.

By J. WALWYN WHITE.

IT may safely be taken for granted that no one will dispute the many advantages that an aerial wire ropeway possesses as a means for economically conveying goods from one point to another, over an ordinary railway or tramway, in point of cost of material and simplicity in laying, especially in rough or hilly country, saving, as it does, all the cost of levelling, bridges over streams, and the cuttings and embankments so necessary to prepare a track for a railway, to say nothing of the saving in severance of land entailed by the latter mode of conveyance.

On the aerial ropeway the material is carried, suspended in mid air, out of the way of ordinary traffic, and without interfering with the occupation or cultivation of the land.

Why then have aerial ropeways been so severely left alone? especially in this country where land is so dear, and where the compensation exacted is so excessive, even for running a tramway across a field.

The answer, especially in the case of heavy traffic, is not far to seek.

Hitherto the exacting conditions requisite for an ordinary ropeway have generally more than counterbalanced the admitted advantages.

Chief among these disadvantages may be mentioned :—

Firstly—The necessity for the ropeway to run in straight lines, curves being impossible without costly angle stations.

Secondly—The very limited capacity in weight-carrying power, the individual loads carried being very small, and the consequent output of material conveyed, very restricted.

Thirdly—The difficulty of taking off branches or turnouts from the main line of ropeway.

Fourthly—The inflexibility of a ropeway, both in alignment of plan and in length.

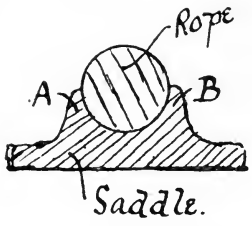
An ordinary ropeway consists usually of a long wire-rope stretched from one point to another, and suspended at intervals along the line of route, over saddles resting on supporting towers of wood or iron. Over the top of this rope, run a pair of grooved sheaves, mounted in a frame, from which the load is suspended. The whole being drawn along sometimes by animal power, but more usually by an endless hauling rope, which travels from end to end of the ropeway, running around a driving drum at one end, and around a tension drum, as it is called, at the other terminal. This arrangement, of course, requires a return carrying rope, which runs parallel with the first rope, and usually about 6ft. or 8ft. from it. The empty boxes or carriers come back by this return rope from the discharging terminal to the loading end, and where the ropeway has sufficient gradient or fall, in favour of the load, the descending loads haul the empty boxes back again. In this case the driving drum already mentioned is replaced by a drum or drums provided with brake gear, and occasionally there is so much extra energy developed by the

falling loads that power may be taken off one or other terminal to drive other machinery.

This briefly describes the usual type of ropeway, more commonly known as the Bleichert system, although in another type of ropeway generally known as the Hodgson or Hallidie system, only one (endless) rope is employed, combining the double function of both carrying and hauling the load. This system, however, is capable of carrying such exceedingly small loads, usually about 100lb. or so of net weight, that I do not propose to deal further with it, although the objections I have given apply equally, if not with greater force, to this system of ropeway.

Now to take *seriatim* the disadvantages of the Bleichert system of fixed carrying rope.

This rope merely rests *on* the supporting saddles, being free to slide through them. The sides or flanges (AB) of the saddles have necessarily to be made very low, in order not to interfere with the free running of the carrying sheaves. If, therefore, the slightest attempt be made to pull this rope out of the straight line—in other words, to turn the slightest angle—it at once mounts the flange, and is drawn out of its saddle, and falls to the ground.



It will be seen, therefore, that a straight undeviating line must be maintained throughout the length of the ropeway (in a vertical plane, of course), a matter very often of great difficulty and entailing a large amount of extra expense in going *over* a hill or other obstruction, which could be saved if the ropeway could only go *round* it. Where, however, it is absolutely necessary to turn a corner, then an expensive "angle station," as it is usually called, has to be introduced, This angle station practically divides the line into two separate ropeway systems. The loads are taken by shunting rails, off one carrying rope, conveyed by manual labour along the shunting rail, to the second carrying rope, fixed at the required angle to the first one, and there attached to the second hauling rope. It will be seen this not only involves expense in the first cost of the angle station, but it limits the carrying capacity of the rope and involves a large addition to the working expenses by the constant attendance of one or two shunters to transfer the loads from one ropeway to the other.

And all this trouble and expense is involved at every corner or angle the line has to make. Truly, a very great disadvantage !

Taking the second objection, as to the small individual carrying power of the ordinary ropeway.

Suppose for the sake of argument that a ropeway be three miles long in a straight line. It will consist of a carrying rope three miles long, stretched from end to end, and suppose, further, that it is required to carry ten ton loads along it, spaced at intervals of 100 yards apart. Quite a small matter compared with a railway, and really a very ordinary condition. And yet the skilled ropeway engineer will at once say, "Impossible, it cannot be done!" Exactly, that is the objection.

Let us see why.

Three miles of rope contains 5,280 yards in length, and if the loads are to be 100 yards apart, there will be

52 loads on the rope at once, or an aggregate of 520 tons in all. Now the straining tension on a carrying rope may be taken roughly at four times the load—depending, of course, on the length of the spans, and amount of deflection allowed. We should, therefore, have a total tension on the rope of some 2,000 tons, less some deduction for saddle friction between the rope and the saddle! It will be seen that we are at once out side the practical conditions of use with a steel wire rope, and hence the impossibility already named, of carrying heavy loads along an ordinary aerial wire ropeway.

I now come to the third objection to the aerial ropeway — the difficulty of taking off branches or turnouts from the main line.

Obviously the only practicable method of doing so, is to establish at the point of turnout, an angle station, as already described, with its requisite attendants for taking the loaded carriers from the main ropeway and shunting them on to the branch line, involving a large expense in working and maintenance.

The fourth objection named will be self evident from the description already given, and this want of flexibility both in length and alignment

FIG. 1.

(objection No. 1) is a very serious drawback in practicable working.

We have now, however, "changed all this," and effectually overcome each of the objections named, by the simple expedient of providing a separate and distinct rope for each

span. The end of each rope is fastened to its own supporting standard, and the span is thus self contained and complete in itself.

The difficulty of course, was to make a good pathway for the carrier wheels from one rope to another,

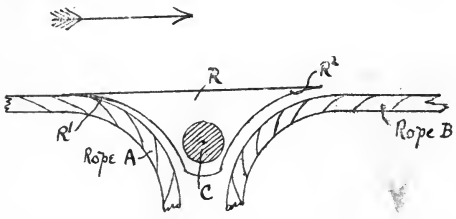


FIG 2.

and after some experimenting, the author designed the simple contrivance of a rocking rail, shown in the photograph, Fig. 1, and in outline elevation in Fig. 2. Here A and B are the two adjacent carrying ropes. turning round the guides on the standard as shown; between them is pivoted at C, the rocking rail R, which is grooved underneath at the ends R^1 and R^2, so as to fit nicely on to the ropes whilst the top of R is turned to the same radius as the rope.

This rocking rail is held normally in the position shown, by a spring or counter-weight, so as to form (as it does in practice) a smooth easy track from the rope to the rail, for the carrier wheels advancing in the direction of the arrow.

As soon as the wheels have passed on to this rail and the weight has advanced beyond the point of suspension C, the rocking rail tips over slightly to the right, so as to rest on rope B, on to which it gives a good lead for the carrier wheels. The counter-weight then brings the rocking rail back to the original position, ready for the next load.

FIG. 3.

Of course it will be understood that the ends of these carrying ropes are not only led downwards by the guides, but also backwards, out of the way of the suspended loads, as shown in Fig. 3. The end of one rope is fastened directly to a hook at the back of the rail at H, whilst the end of the next rope has a short length of open link chain attached as shown at K. When it is desired to tighten up the rope from wear, etc., a straining screw is attached to the chain, and connected to the base plate. It is then tightened up a link or two and fastened by passing the nearest link in the chain to the holding hook K on the standard, and the thing is done.

When the rope has been in use for some time, and begins to show signs of wear, where the end of the rocking rail rests upon it—a few links of chain are attached to the dead end of the rope, so as to allow it to be moved a few inches along, through the guides in order to expose a fresh surface to the rocking rail, and at the same time the rope can be given a quarter-turn round along its whole length, so as to present a fresh surface for the carrier wheels to run upon. This is simplicity itself. And now let us see what advantages such a system gives us over the old order of things.

1. A much lighter carrying rope may be used, as it need only be strong enough to carry the strain due to the greatest load that can come on one span at a time.
2. A much flatter catenary curve may be obtained, as a larger relative tension can be put upon the carrying rope without unduly straining it.

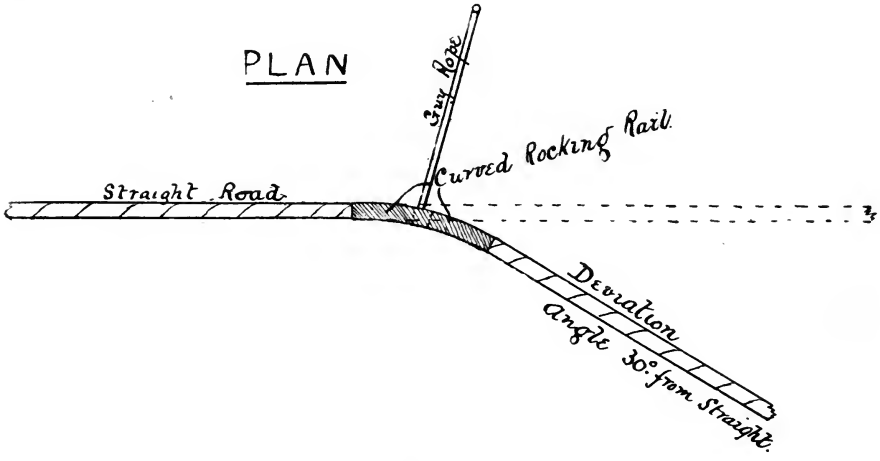


FIG. 4.

3. Should any part of the carrying rope get worn or broken, it will be only necessary to replace the rope of the one defective span, instead of, as at present, having to renew the whole rope or splice new portions into it, entailing a stoppage of the whole line while this is being done.
4. Curves can be readily made without the necessity of special angle stations, as at present required.
5. "Turn-outs" or "pass-byes" can

be taken from any post, it being only necessary to substitute a switching rail for the ordinary rocking rail at the post.

6. Much larger individual loads can be carried on the single rope, and in case of extra large loads of (say) 15 to 20 tons, the weight can be equally divided on two or more ropes (one rope vertically underneath the other) as shown in the accompanying drawings Figs. 7, 8 and 9, and photograph Fig. 14.
7. Each post and its attachments being all self-contained, the ropeway can be readily removed about from place to place, thus forming a *portable* ropeway.
8. Owing to the short sections of ropes in use they can be readily turned round from time to time to ensure equal wear all round.
9. The separate ropes may be insulated from each other, when an absolutely automatic block system of electric traction is at once provided; one rope carrying the positive current, the other rope carrying the negative or return current.

It would be well to inquire how these advantages which I claim may be substantiated.

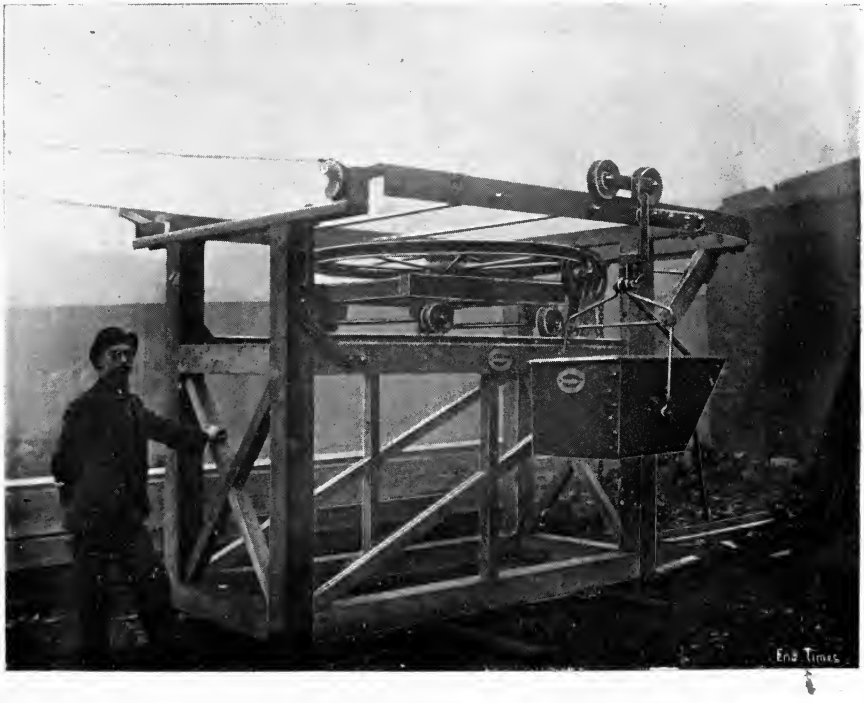


FIG. 5.

The *first*, *second*, and *third* items are self evident, and will doubtless be readily admitted.

The *fourth* advantage that "curves can be readily made, without the necessity of special angle stations as at present required" may possibly need some explanation, although it is really very simple.

As we have seen, a curve or angle cannot be made on an ordinary ropeway, because the rope would be at once drawn out of its saddle, were a deviation made from the straight line, but in this case, the ropes are passed over guides leading backwards, and the ends fastened, so that they could not possibly be drawn out. All that is necessary, therefore, is to lead off the rope to the required angle, and to make the connecting rocking rail *curved* to suit the angle, see Fig 4. In the case of a relatively sharp curve, the rope guides may be turned to a corresponding angle, though for moderate change of direction this is not necessary. A guy rope is then fixed to the back of the standard, as shown, and to take up the side strain, and, if necessary, a vertical guide roller may be placed on the front of the standard to keep the hauling rope within proper bounds.

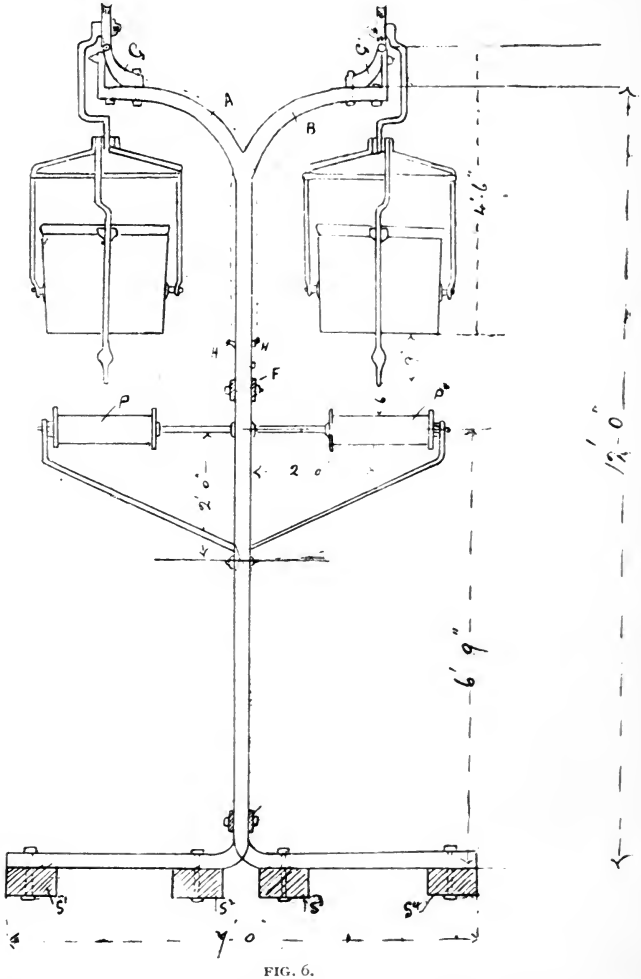


FIG. 6.

The *fifth* claim will now probably be admitted after this explanation, the cases being somewhat similar, and the same figure, No. 4, will show the arrangement, whilst the *sixth* claim will doubtless also be allowed on inspection of the drawing: Fig. 15, showing details of a ropeway we have designed for competition for a Government departmental inquiry and of which the following is a brief description of the conditions required.

The line of ropeway is to be half a mile in length in spans of 200ft., the supporting towers of steel to be 24ft. high. The whole is to be capable of carrying 10 ton gross loads, and arrangements are to be so made, that a branch line of ropeway can be taken off at any supporting standard, and at the same time the whole plant must be so portable that it can be readily removed during the winter, and re-erected again for work in the summer.

In the case where still heavier loads have to be carried, the loads can be supported on two ropes instead of one, as shown in the Figs. 7, 8 and 9.

The weight of say (20) tons is *equally* divided between the two ropes, the ends at one standard being connected together and passed around a pulley sheave, thus ensuring that the strain on the two ropes shall always be equal.

This brings us to our next claim, No. 9, that a system of absolute block

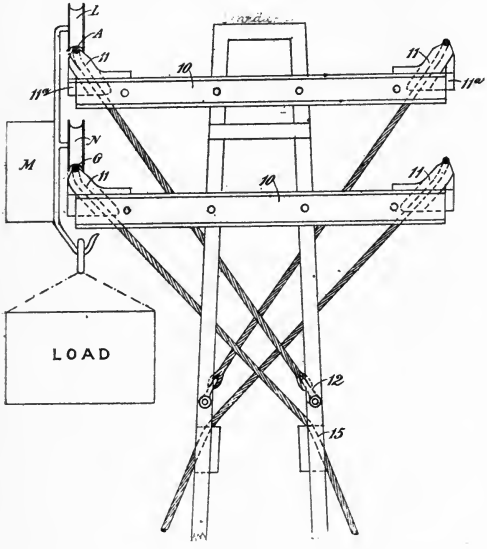


FIG. 7.

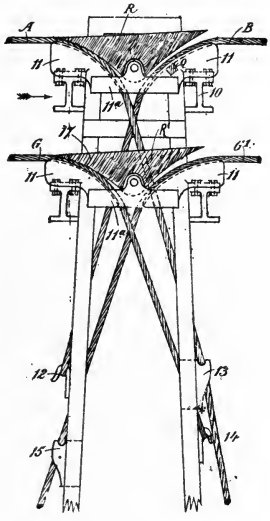


FIG. 8.

electric haulage is provided. In this case the top carrying ropes are carried over varnished or paraffined oak guides, in order to insulate them from each other, the bottom carrying ropes going over the usual steel guides, and, in fact, are preferably electrically bonded together with copper bonds, so as to provide a complete metallic circuit for the return current to the dynamo. The positive current is taken from the dynamo by a separate insulated electric cable running the whole length of the ropeway, and branches from this convey the electric current to every *alternate* rocking rail. It will be seen that only the span rope on which the feeding rocking rail is resting can be supplied with electric energy, whilst the adjacent rope, having no electric circuit to it, is dead. An absolute automatic block is thus provided, as shown diagrammatically in Figs. 1, 11, and 12. Here A, B, C, and D represent the top ropes of four spans of ropeway, electrically insulated from each other, whilst the bottom rope is shown by G, G', the different spans of this being electrically connected into practically one rope. K is the separate main electric cable, and branches go from this to the *alternate* top rocking rails, E and F, as shown.

Suppose the load to be on span A (Fig. 10), the current will go from K, through the rocker E, which makes electrical contact with rope A conveying the current to it, thence through the wheel L of the carrier, through the motor M, bottom carrying wheel N to the return wire G,

and so back to the dynamo. (See also Fig. 7 for these connections.) The motor M is connected with worm gearing to the two driving wheels L, and N, which are thus driven round as shown in Fig. 14.

The rocker E is held normally by a counter-weight in the position shown in the drawings, Figs. 10, 11, and 12 (of course exaggerated), but when the advancing load tips it over into the position shown at E (Fig. 11), it is held there by an electro magnet shown at Q (Fig. 8) which is in electrical connection with rope B, and E is thus held down in this position (Fig. 11) as long as any current is flowing through the magnet, or rope B.

The current is thus cut off altogether from span A, and consequently no load can travel along it, so long as there is a load on span B.

When, however, this load has advanced to the next span, C (Fig. 12), there will be no current going through B (the electricity now coming via rocker F), so the magnet Q will lose its power, and rocker E will fall back to its original position and once more energize span A.

There is thus provided an automatic and perfectly effective absolute block system, the passing load making its own electric connections without shock, stoppage or reversal of current, or sparking, and no load can ever get within a clear span, either of the load in front of it or of the load behind it.

Each load can, therefore, be despatched on its journey without requiring the attendance of a man in charge.

In order to overcome the ascending gradient on the approach to a standard, the spans are all made of approximately equal length, and two

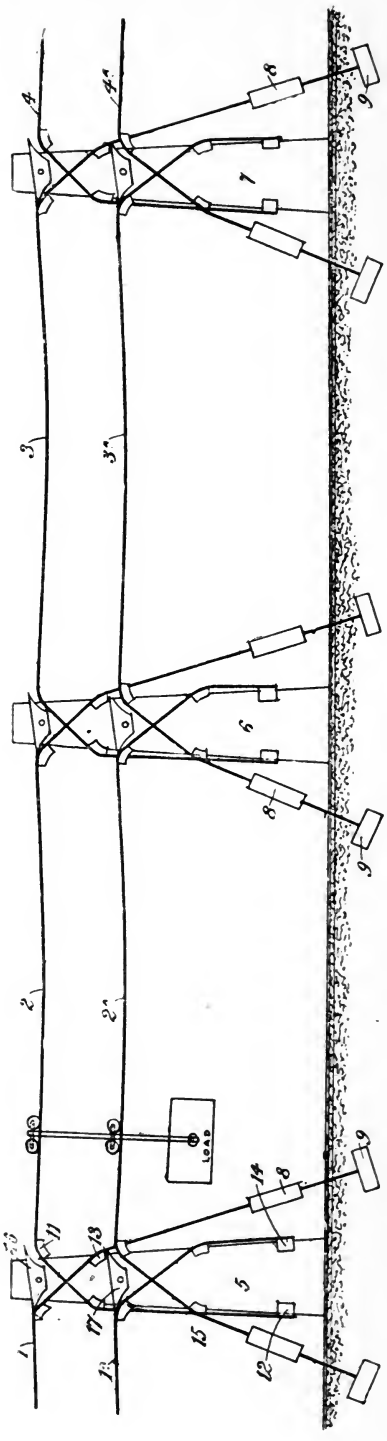


FIG. 9.

loads connected together at half span distance, as shown in Fig. 13, so that as one load goes down hill it will pull the other up, and *vice versa*. If desired the latter load may be merely a trailing load, only the one carrier being provided with an electric motor.

'Having thus proved our claims to the advantages we have named for our system of ropeway, let us see if we have successfully overcome the disadvantages we quoted at the outset to belong to ordinary ropeways.

The first of these—that of the necessity of the ropeway to run in straight lines—is disposed of by our fourth claim. The second objection—of limited weight carrying power—is completely got over by our sixth claim, proving our ability to carry individual loads of 20 tons each, and my firm (R. White and Sons, of Widnes) is now prepared to supply any ropeway for any loads up to 20 tons each, with an output of 10,000 tons per day of 10 hours, if necessary. The third objection is completely met by our fifth claim, and the last objection—as to the inflexibility of the ordinary ropeway—is completely answered by our fourth and seventh claims.

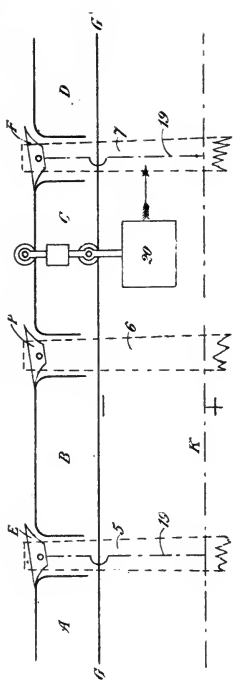


FIG. 12.

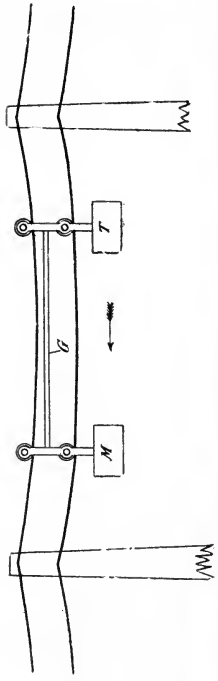


FIG. 13.

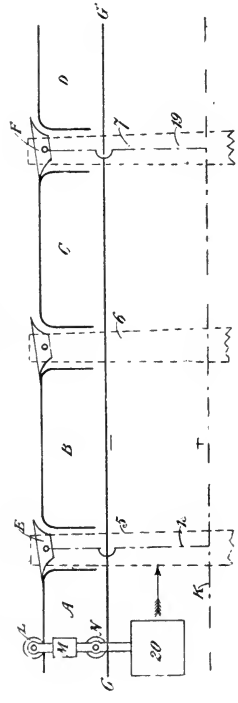


FIG. 10.

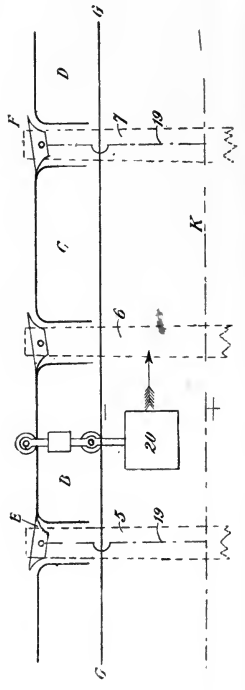


FIG. 11.

With regard to this last, it may be pointed out that, by our system, a ropeway can be built up, section by section, as it proceeds along, the materials for a new section being conveyed along the finished ropeway, span by span, thus saving a large item of expense in conveying materials into distant countries, and avoiding the necessity for conveying a length of several miles of rope, weighing several tons, on mules' backs, over mountain tops, as is now occasionally required.

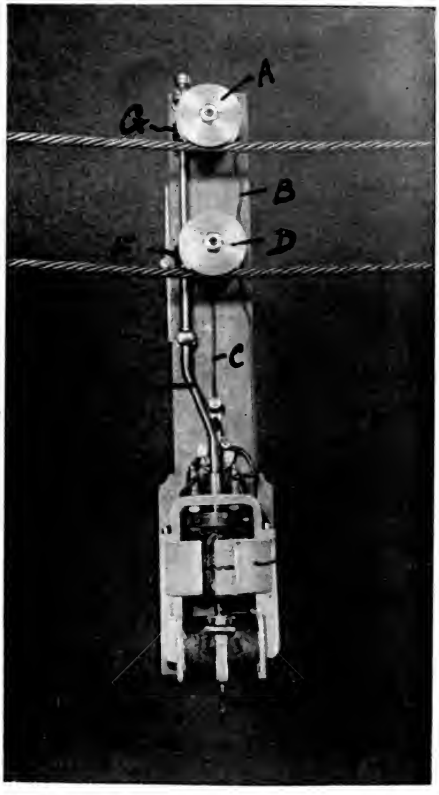


FIG. 14.—FRONT VIEW OF ELECTRIC MOTOR.

The electric current travels along the tight rope, thence to the top carrying wheel A, down the insulated lead B to the motor M. It returns by lead C to the bottom wheel D, and so along the bottom carrying rope, to the dynamo.

The armature of the motor is connected to the flexible shaft E which drives the two worm wheels F and G, which gear into pinions on the wheels A and D which are thus driven around.

The load is attached to the carrying hook K.

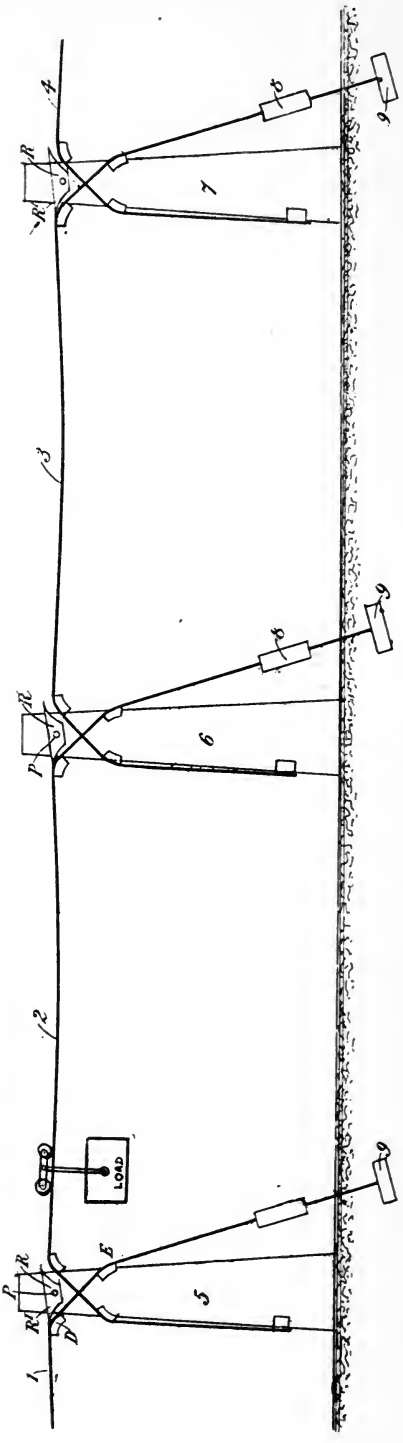


FIG. 15.

Further, a span need only be made a part length at first, where necessary, the extra length of rope for the full span being coiled up at one end, ready for use when required, as shown in Fig. 3.

I have only dealt here with the question of carrying rope, which is, of course, the main question, the matter of hauling rope and connections with the loads being ordinary matters of everyday practice with ordinary endless rope haulage.

I show in Fig. 15 a diagrammatic elevation of a length of ropeway, showing the separate ropes for each span on which the load is carried, and in Fig. 9 a similar view, where the load is carried on two ropes, from which it will be seen that the ends of the carrying ropes may either be attached to the standards themselves, or carried down to the ground and anchored there, according to local circumstances.

There is no limit to the length of the spans that may be used, but practical considerations decide a span of about 100 yards or so, as being the most convenient, although by this system of separate ropes, much larger spans than usual, can be readily employed, if required.

It is surprising what a poor opinion of ropeways a lot of works managers possess. I suggested to a firm the other day, who at present are carting about 500 tons of stone per day a distance of two miles from their works to the railway, by means of horse carts and traction engine, that they should adopt an aerial wire ropeway for carrying their goods down. I was met by the reply that there was a want of finality in such a scheme, as a ropeway at best could only be a temporary arrangement, and they would before long require to carry down something like 800 to 1,000 tons per day. My answer to this was that my firm would guarantee to supply and equip a ropeway complete, capable of conveying 1,000 tons of material per day of 10 hours, at less than a third of the cost of a railway (to say nothing of the cost of the land), and that we would guarantee the working expenses including interest on the amount, with proper allowances for depreciation and maintenance, not to exceed 2d. per ton per mile for goods conveyed. I was then met with the reply that they were afraid that a ropeway conveying such a quantity of material would require to be constantly renewed; my answer to this being that we would guarantee the carrying ropes to convey an aggregate weight of not less than 400,000 tons before the carrying cables required any renewing; whilst of course the supports, terminals and carriers would be good for a much greater weight, so that even the cost of renewing the cables would only be relatively a small matter. I further undertook that such a line, with a good falling gradient in favour of the load, would require only a brakesman and a despatching man for the carrying boxes at the delivery terminal; that the boxes would go to the discharging end of the line, there automatically tipping their contents into the storage hoppers, and the empty buckets returned to the despatching terminal without any attention whatever; the tipping of the material being done automatically at any point required.

I think that such a statement as this has greatly altered my friend's view that a ropeway is nothing but a toy.

J. Walwyn White.

SINGLE-SPAN CABLEWAYS: TRAVELLING, FIXED AND SEMI-PORTABLE.

By S. M. COCKBURN, Assoc. M. Inst. C.E.

THE "Cableway" may be defined as a hoisting and conveying device, employing as a trackway a suspended cable in one span. What are known as "wire rope tramways," "wireways," "ropeways," whether inclined or otherwise, have no capacity for hoisting, and are limited to the sole function of conveying, and unlimited in the number of spans.

In the present article I will deal with the cableway only, and particularly with a few installations which I had the pleasure of seeing in operation in America a year or two ago. I am to a certain extent compelled to deal with American practice, as British engineers and contractors have yet to fully appreciate the cableway as a means of hoisting and conveying materials.

The cableway has a very wide range of uses, and up to the present has proved valuable in bridge, canal, lock, dam, pier and wall construction, quarry and open pit mining, such as iron and phosphate mines, excavating and conveying sand and gravel, sewer and trench excavations, and the conveyance of goods from one warehouse to another, and such uses.

Wire rope tramways date back to the early part of this century, and inclined cableways of short span and for comparatively small loads have been in use in quarries both in this country and America for the last 30 or 40 years, but the first cableway of large span and for handling heavy loads, was designed and constructed by the Lidgerwood Manufacturing Company of New York, and so many excellent improvements have been made in the speed and capacities of the machine that the Lidgerwood Cableway is now considered to be the most perfect one of its kind available at the present time. I shall therefore confine my remarks to this system.

Before proceeding to deal with some of the interesting installations and apparatus which have come under my notice, it may be interesting to give one or two points which might assist intending purchasers to obtain the most suitable available systems for their particular work at the proper price. If an estimate for a ropeway is required particulars should be given of (a) the span or

distance between towers; (b) the maximum load (tons) to be carried; (c) the average load (tons); (d) the daily capacity desired (tons); (e) whether the load is to be delivered at one point or several: (f) whether the load is to be taken from one point or several; and (g) what the nature of the material is which has to be handled; and in order to enable a maker to clearly design the most efficient installation a profile sketch or drawing of the proposed cableway, with at least approximate distances and elevations, should be supplied. Makers of systems will then be placed in a position to state what they are best able to do respectively to suit each particular case.

In 1890 the Lidgerwood Manufacturing Company constructed the first travelling cableway. It was made to the order of the contractors of the Chicago Drainage Canal, and so successful did it prove that in a short time over twenty similar plants were erected along the canal. The requirements specified by the purchaser called for a machine having the ability of moving readily parallel to the direction of the proposed cutting at a rate of 2½ft. to 5ft. per day, and being capable of handling 300 cubic yards per day. It was found on trial, however, and after a few improvements had been effected, that (where the material broke favourably under the blast) as much as 600 yards could be handled.

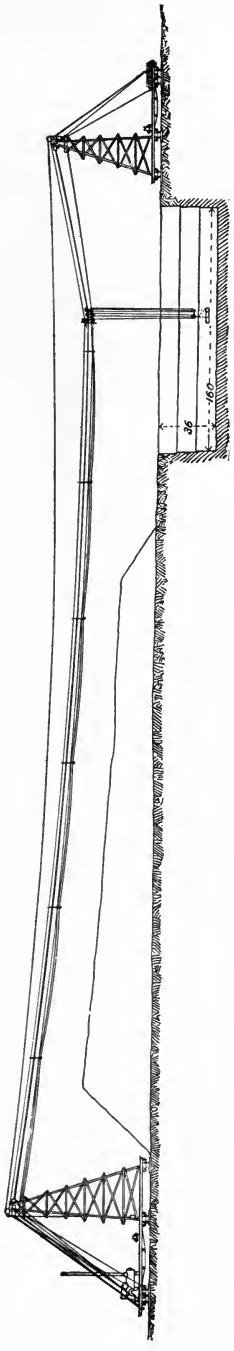


FIG. 1.—THE LIDGERWOOD TRAVELLING CABLEWAY AS USED IN THE CONSTRUCTION OF THE CHICAGO DRAINAGE CANAL.

The sketch (Fig. 1) gives a general idea of the travelling cableway used in the construction of the Chicago Drainage Canal.

The span varies somewhat on the different sections, as it is governed by local conditions, but is generally 700ft., the head tower being 93ft., and the tail tower 73ft. high. The head tower is the one carrying the engine, and is made higher to add to the size of the spoil bank as the material is spo led on that side of the canal. The main cable, on which the carriage travels, is 2¼in. diameter steel, and the other ropes are of suitable size to handle a load of eight tons. The operating power is furnished by a 10×12 double cylinder hoisting engine, which I will refer to hereafter, and the steam is supplied by a locomotive fire-box boiler rated at 70 h.-p. A three-wheel carriage is used, and "Miller" fall rope carriers, modified to accommodate an extra line for dumping, serve to render it easy to lower the empty fall block rapidly at any point.

The dumping is effected by an auxiliary rope called

the dump line, which is attached to the rear end of the skip or tray. When it is desired to dump the latter this line is drawn in at a higher rate of speed than the hoisting rope, the skip is tilted, and the load dumped without stopping the onward progress of the carriage on the cable.

Each of the towers is moved by small reversible engines, with $6\frac{1}{4} \times 8$ double cylinders and compound geared to give high pulling power with a small amount of steam. It has reversible link motion and a winch drum. On the head tower steam is taken from the main boiler, while on

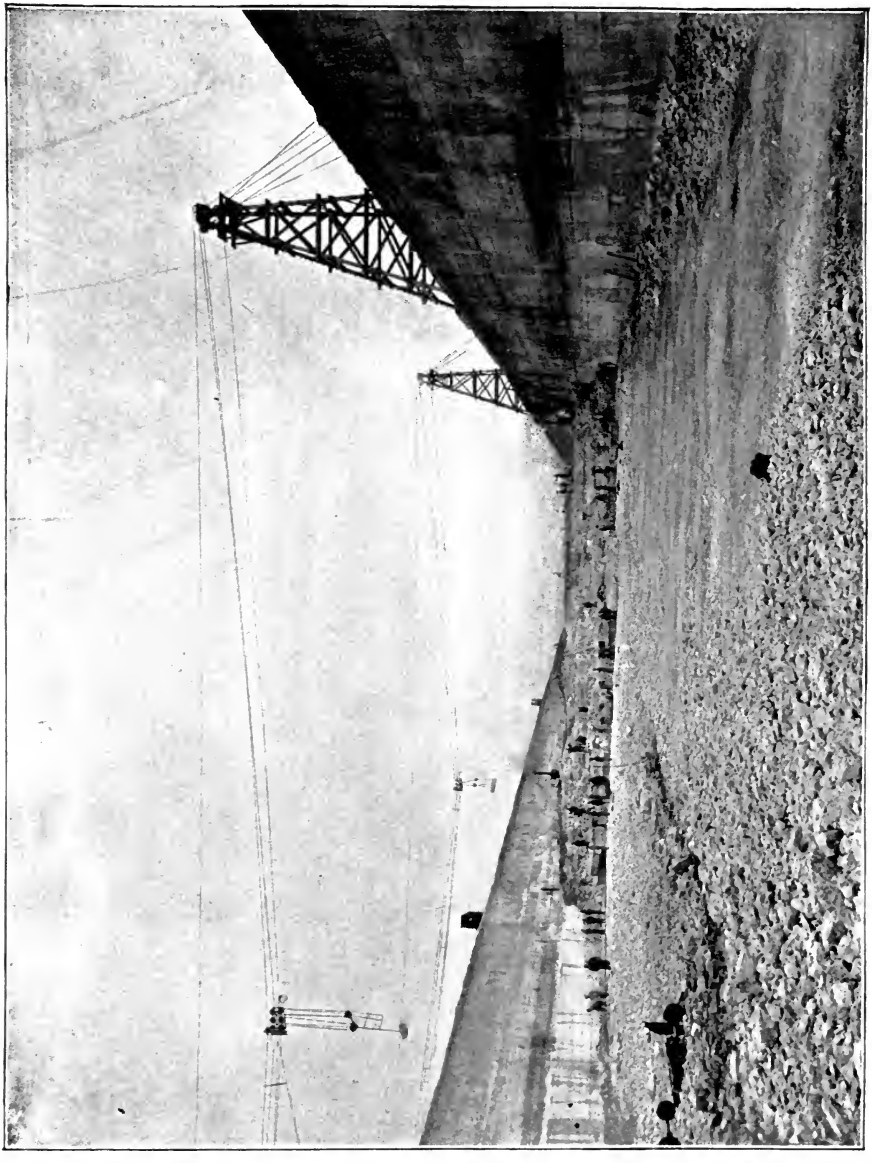


FIG. 2.—CHICAGO DRAINAGE CANAL: VIEW FROM THE BOTTOM OF COMPLETED ROCK CUT SHOWING TRAVELLING CABLEWAYS.

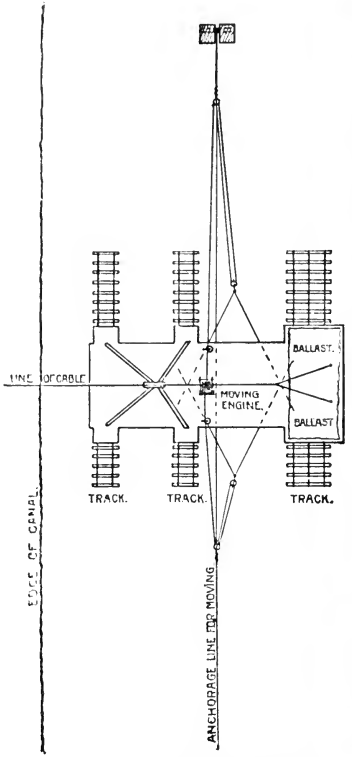


FIG. 3.—PLAN OF ROPES FOR MOVING.

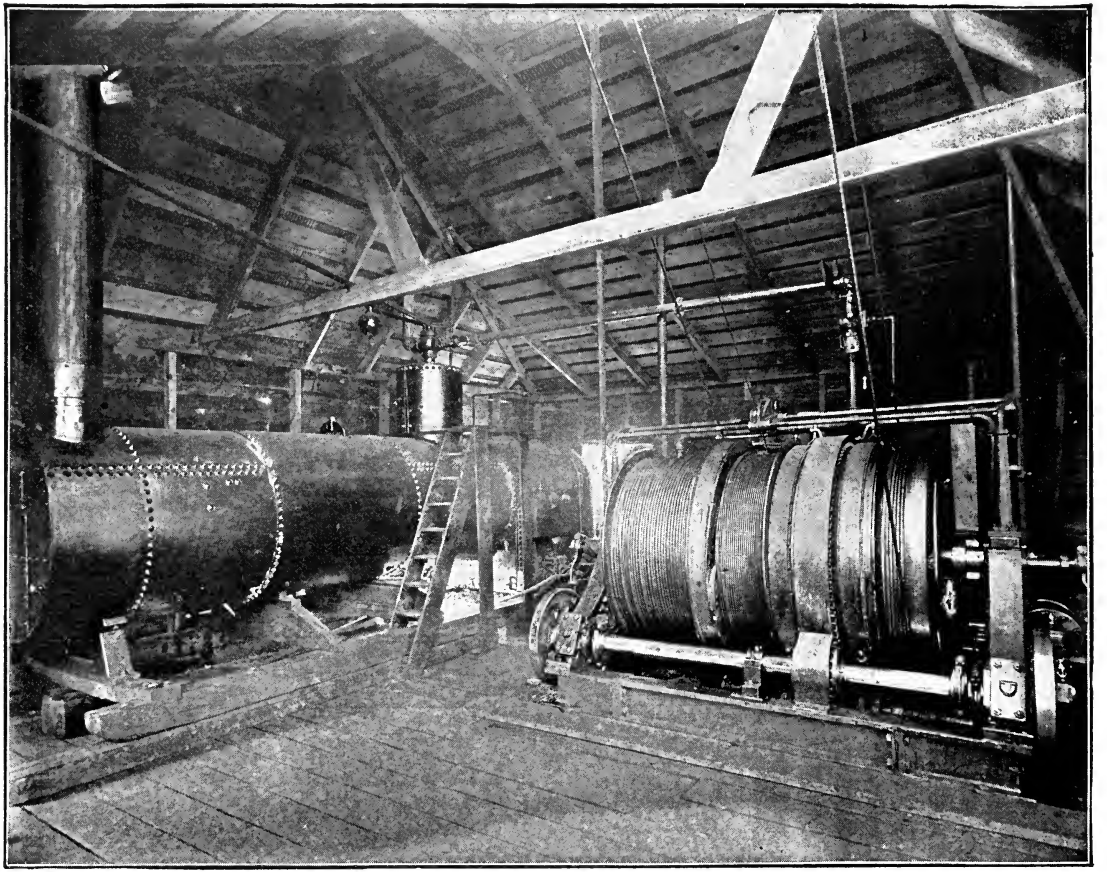


FIG. 4.—INTERIOR OF ENGINE HOUSE—TRAVELLING CABLEWAY.

the tail tower the engine is run by compressed air from the drill pipe which runs along the canal.

A $\frac{3}{4}$in. diameter steel rope is stretched under the centre of the car parallel to the line of the canal, for several hundred feet, and anchored at each end to a deadman. A bridle leads from under the car in each direction. The ends of the bridle are attached to the timbers of the car, one end under the inner posts, and the other to the timbers carrying the rear axles. A pair of single blocks are attached to the bridle and to the anchorage line on each side. A rope is woven through the single blocks on one side, then several times around the drum of the engine, and through the blocks on the other side, as shown by the sketch. (See Fig. 3.) As the engine is reversible, the tower may be moved in either direction, at a speed of 50ft. per minute, but a greater speed could be had if desirable.

The track is either laid for some distance ahead of the machine, or more frequently, 15ft. sections permanently attached to the ties are used, and transferred from one side of the car to the other.

The illustration (Fig. 4) shows the interior of the engine-house on the head tower, and presents a good view of the specially-designed engine used in working the loads on these travelling cableways. As already stated the latter has 10 by 12 cylinders with cranks connected at an angle of 90 degrees, and is fitted with reversible link motion. The drums are

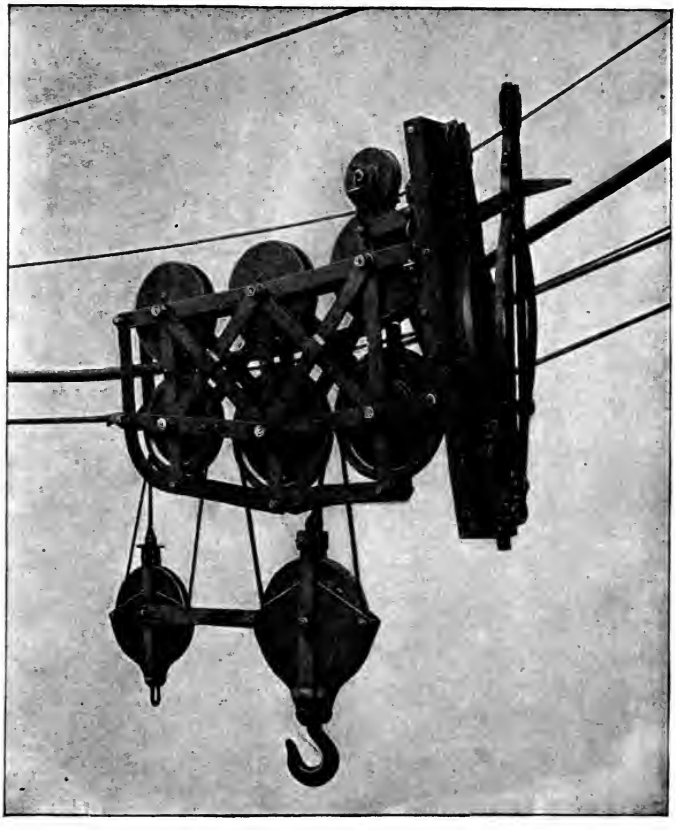


FIG. 5.—CABLE CARRIAGE AND FALL ROPE CARRIERS.

Beekman patent friction type with strap brakes, and can be operated either together or independently. The two drums being of the same diameter the ropes travel at the same rate of speed when both drums are revolving, and the load may be carried in either direction at a uniform distance from

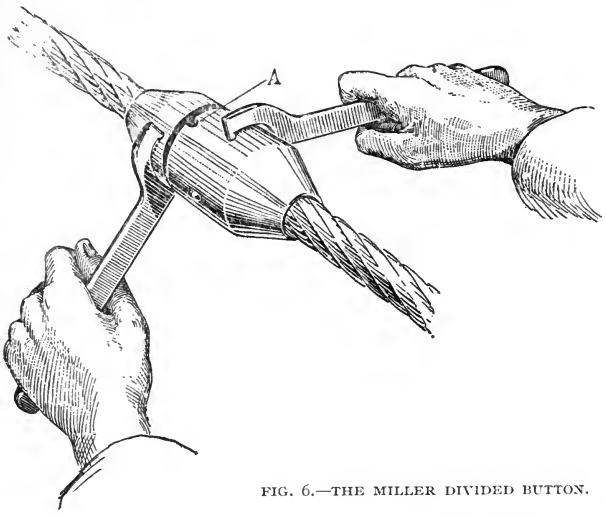


FIG. 6.—THE MILLER DIVIDED BUTTON.

the cable. The endless or traversing drum is shown at the right. This drum is turned with a curved surface, around which the endless rope is wrapped five or more times to secure sufficient friction to keep it from slipping in the opposite direction to that in which the drum is turning. The hoisting drum is divided into two parts; the wider part receives the main hoisting rope, and the narrow part the dump line. Between these two parts of the hoisting drum is the portion of the drum with the increased diameter on which the dump line is shifted when the skip is to be dumped. The shifting mechanism is shown on top of the engine, and all operating levers are assembled in a rack in a convenient position at the rear of the engine.

The engine is designed to lift eight tons at a speed of 300ft. per minute, and to convey it along the cable at a speed of 1,000ft. per minute; but with increased steam pressure it works at much higher speeds. The boiler is of the locomotive fire-box type, 70 h.-p., and supplies steam for both cableway engine and the moving on the head tower.

These cableway engines are fitted with a patent oiling device for the friction pins, which prevents heating and burning out of the points when running continuously at high speeds.

Important features of the Lidgerwood cableways are the carriages and fall-rope carriers,

FIG. 7.—AN AERIAL DUMP.

illustrated in Fig 5. The former are light in proportion to strength, and are capable of hoisting eight tons. All the wheels are brass bushed into self-oiling bearings. Attention has also been paid to effect simplicity in construction so that it may be easily repaired in case of accident. The fall-rope carriers,—designed and patented by Mr. Spencer Miller,—are used exclusively on all Lidgerwood cableways, and are light and strong, and have suitable wheels for supporting the hoisting or fall rope, the dump rope, and also the endless or traversing rope. They ride on the horn shown in front of carriage until they are displaced by means of the steel buttons on the button rope. The spaces in the carriers are graduated in size, as are also the buttons, so that each button will pass through every carrier except the one which it pulls off the horn of the carriage. The buttons being made fast to the rope at regular intervals—suited to the requirements of the cable-

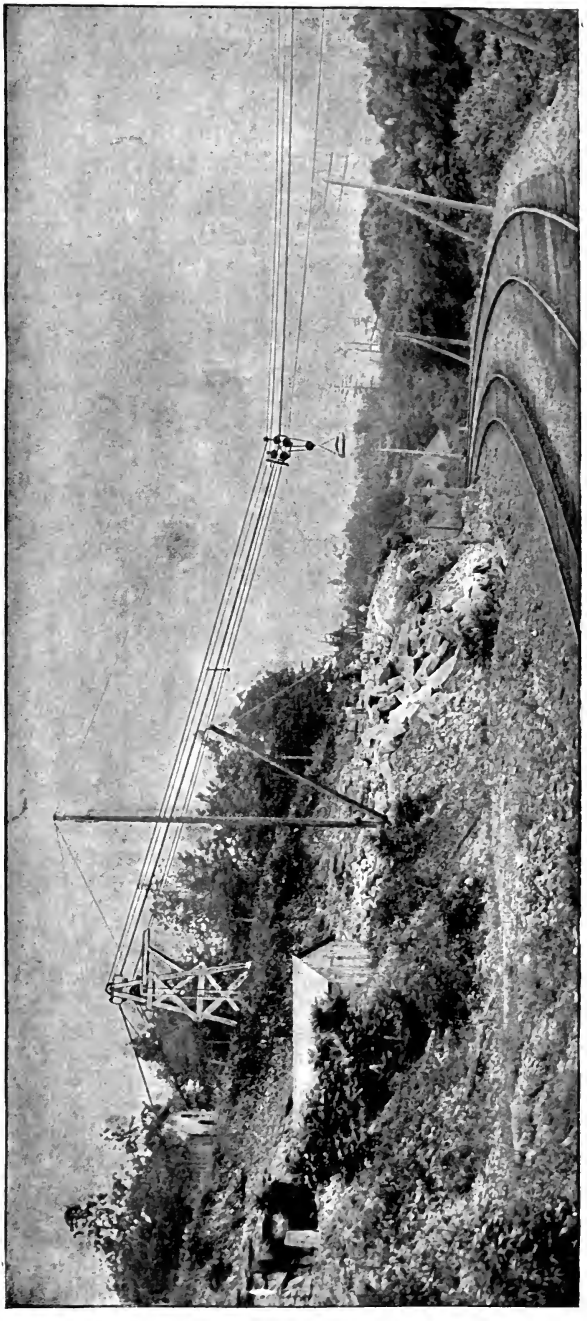


FIG. 8. SHOWING AN ORDINARY CABLEWAY SUSPENDED ACROSS THE MAIN LINE OF A RAILWAY, AND WORKING WITH ABSOLUTE SAFETY.

way—it is evident that as the carriage passes along the carrier will be displaced from the horn at each button, and hence the ropes will be perfectly supported. The illustrations of the button (see Fig. 6), are so explanatory as to render a detailed description of it unnecessary. As the carriage moves in the opposite direction the carriers will be picked up by the horn on the carriage as fast as reached. The importance of these fall rope carriers will be seen when it is considered that if the fall rope were allowed to sag down for any distance it would simply be impossible to lower the fall block, and the cableway would be inoperative, in addition to which would be the great wear on the rope from chafing on the ground, the danger attending same, etc. By the use of these carriers the speed at which the cableway could be operated was not in any way limited. A few remarks may be opportune regarding the aerial dumping of loads. The carriage is moved along the cable by an endless or traversing rope, which passes from the carriage over the head tower, and several times round a winch drum on the engine to secure frictional hold, then back over the head tower to the tail tower, and then returns to the rear end of the carriage. A hoisting rope passes from the engine over the carriage to the large fall block for raising the load. An auxiliary hoisting rope, the dump line, comes from the other side of the same drum of the engine, and passes to a smaller block attached to the

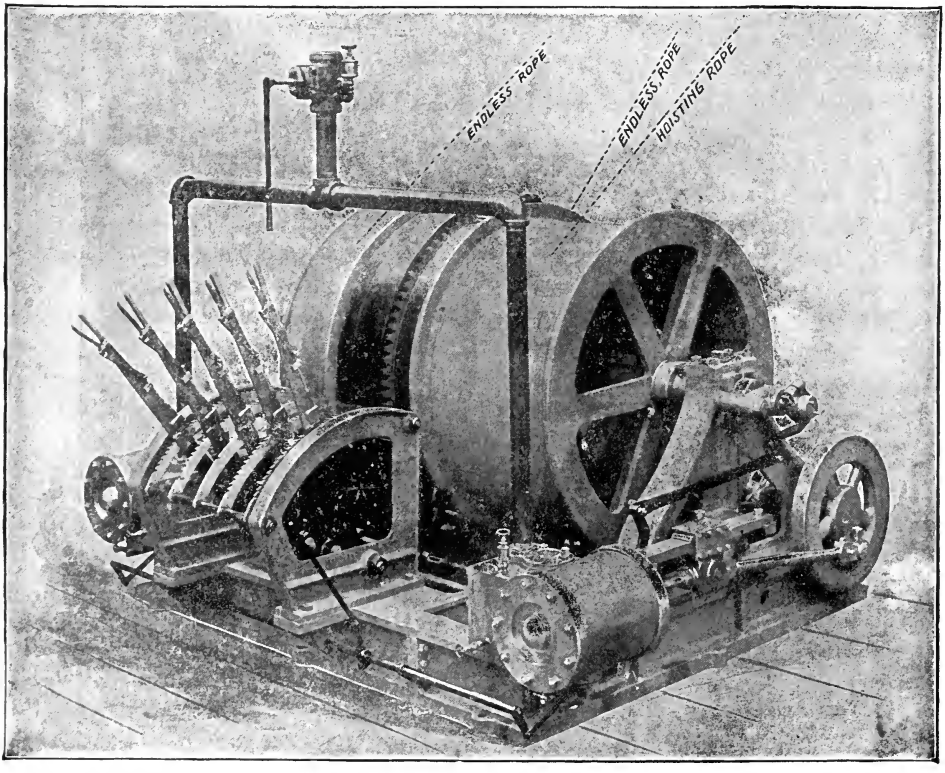


FIG. 9.—THE "LIDGERWOOD" ENGINE USED FOR ORDINARY FIXED CABLEWAYS.

rear end of the skip. This line is shown in the illustration (Fig. 7) just below the cable. The hoisting rope carries the whole weight of the skip, and the dump line comes in slack, but at the same rate of speed. When the spoil bank is reached, the dump line is thrown on an increased diameter of the drum, and being thus drawn in at a higher rate of speed, the load is discharged. The load is dumped while the carriage is in motion, and the engine is immediately reversed, the carriage returning for the next load without the slightest delay.

The button rope is just above the cable, one carrier is shown arrested by a button, while the others have already been picked up by the horn of the carriage.

The skip is made of boiler plate about 7ft. square, 2ft. in height, and has an average capacity of about 1·8 yards "place rock."

The travelling cableways have done excellent work on the Chicago Drainage Canal, and the cost of operating them has proved that they are superior to any other methods employed for similar work. The total operating cost for labour, coal, oil, waste, etc., may vary from £3 to £3 15s. per day, the capa-

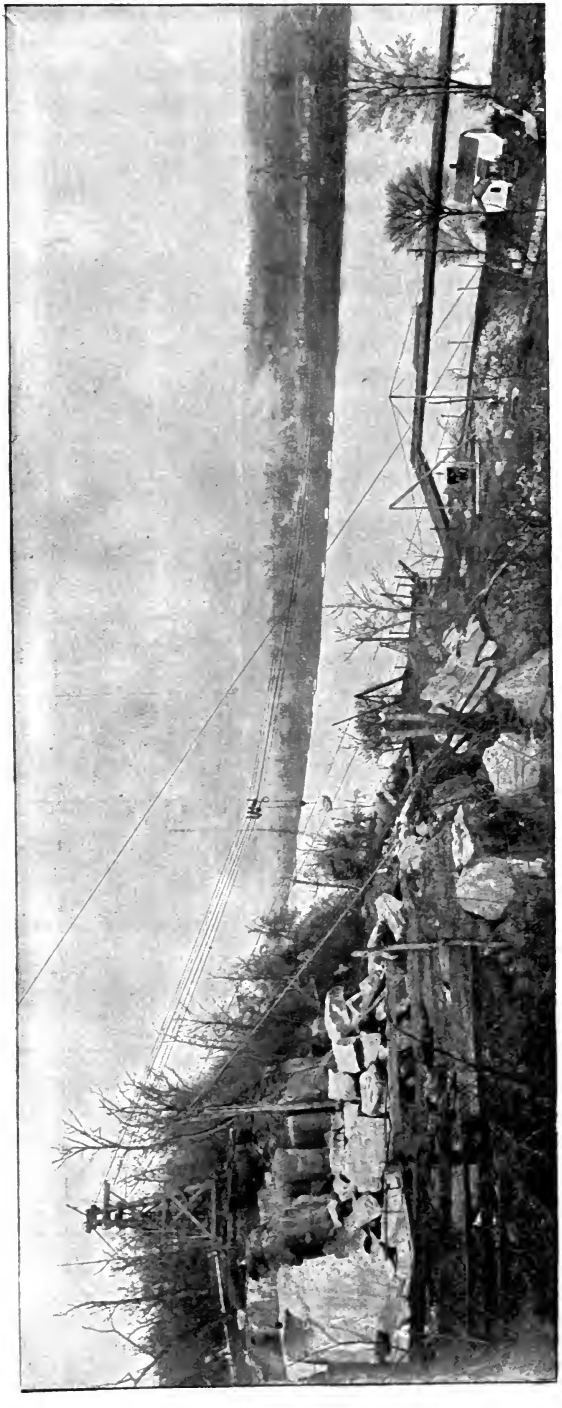


FIG. 10.—THE LONGEST HOISTING AND CONVEYING CABLEWAY IN THE WORLD. SPAN 1,505 FT., MAXIMUM LOAD 4 TONS.

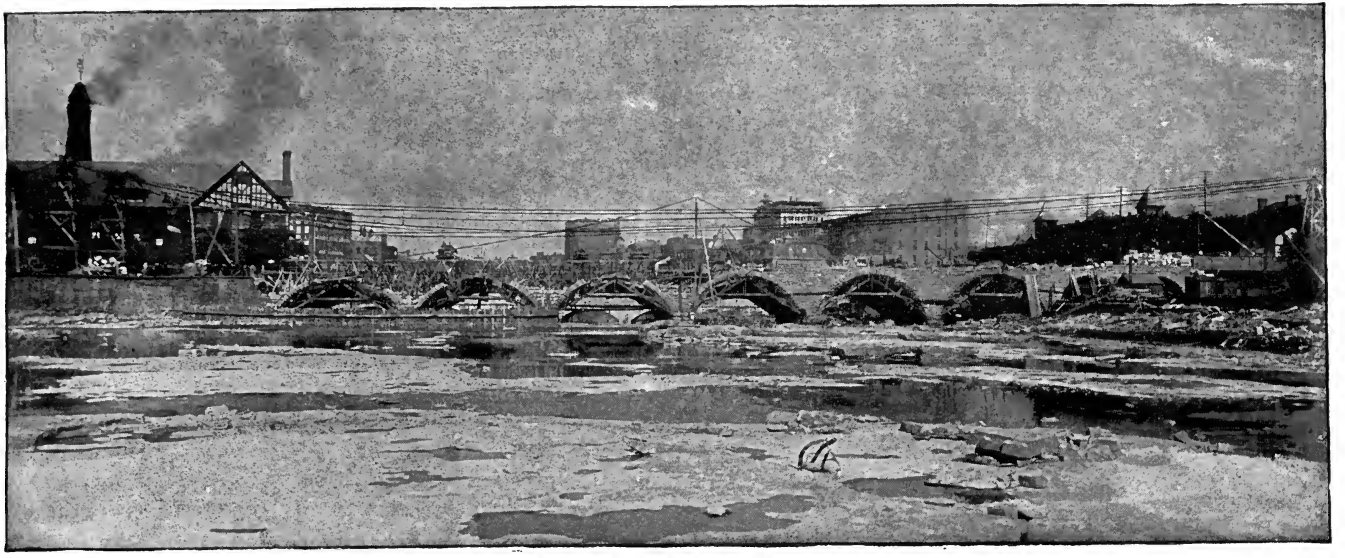


FIG. 11.—VIEW SHOWING CABLEWAY BEING USED IN BRIDGE REDUCTION AND RECONSTRUCTION.

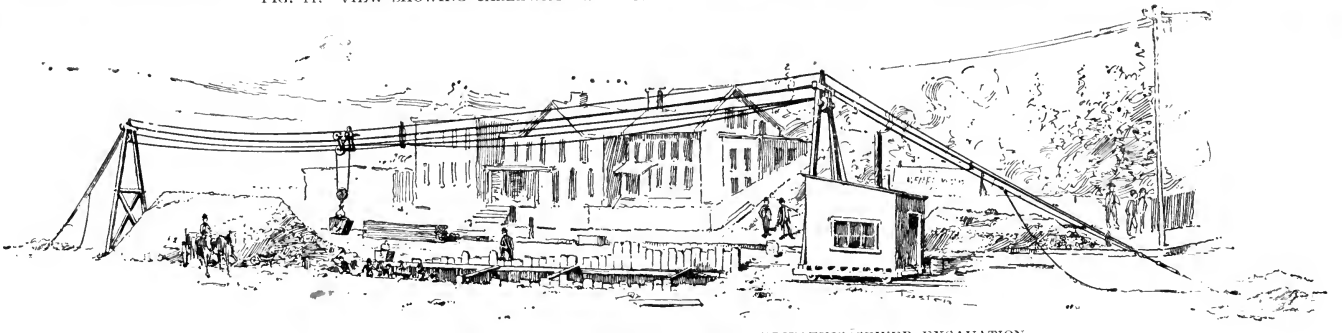


FIG. 12.—A SEMI-PORTABLE CABLEWAY SHOWN FACILITATING SEWER EXCAVATION.

city may vary from 400 to 600 yards per day, and it may therefore be assumed that the cost per cubic yard for these items is about twopence per yard. The cost of operating at night is practically the same as during the day, and about the same amount of material can be handled, the only additional expense being a slight amount for lights. The cableway has proved itself 5½d. to 6½d. cheaper per cubic yard of rock handled than the inclines, and on a run of several months, has shown itself 2¼d. *per yard cheaper* in the cost of operation than *any of the other methods employed* for the same work, while the outlay for plant was much less.

The illustration (Fig. 8) represents a 3½ ton cableway installed at quarries at Old Forge, Pa., and designed to transport stone across the main line of a railway company, in order to reach the tracks of a competing line with whom it was more desirable to make shipping arrangements. This plant, which has been in successful operation for several years, is another example demonstrating the absolute safety insured in using a properly-designed suspension cableway continuously over the main line of a railway or public thoroughfare. There need be no obstruction to travel, nor yet danger to traffic or passers-by.

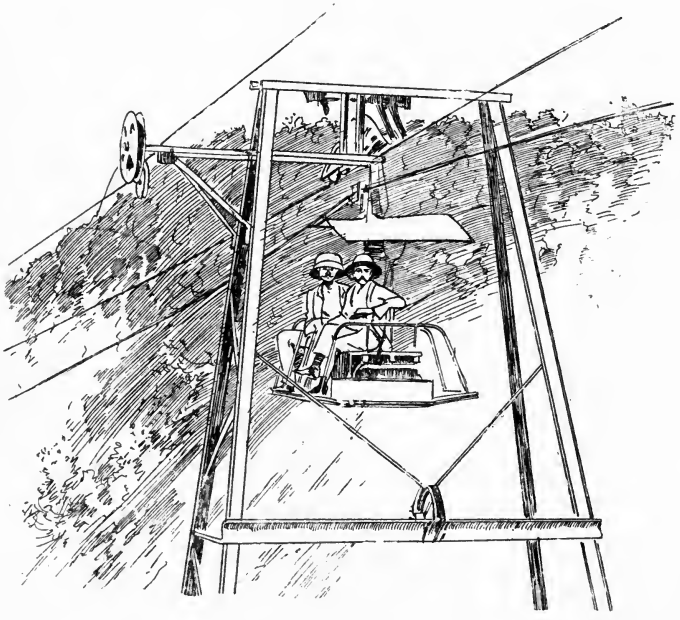
Where aerial dumping is not required, the hoisting engine shown in Fig. 9 is used in a Lidgerwood cableway installation. This engine has double cylinders, with cranks connected at an angle of 90 degrees, and is fitted with reversible link motion. The drums are of the Beekman friction type, one to carry the hoisting rope and the other is turned with a curved surface, as shown in the engraving, and carries the endless rope.

The hoisting and conveying cableway, shown in Fig. 10, is claimed by the Lidgerwood Manufacturing Company to be the longest in existence. It is suspended over the Kanawha River, W. Va., and has a clear span of 1,505ft. The main cable is 2½in. in diameter, and has carried loads of 4 tons.

The illustrations (Fig. 11) show the application of the cableway to bridge construction. The bridge depicted in course of building is the Court Street Bridge over the Genesee River, at Rochester, N.Y. Two Lidgerwood cableways were used. They were identical in every respect and independent, except that one boiler supplied steam for both. The capacity or maximum load handled by each was four tons, which was the weight of some of the heaviest blocks; the smaller stones and other material, such as cement and gravel, were loaded into skips, which were suspended from the fall block of the carriage. All material, although the bulk of it came from one side, was picked up and delivered at any point along the line with the greatest ease and entirely under the control of the engineer, a conveying speed of 600ft. per minute being easily attained. The wooden towers at either end for the cables were 50ft. high, and were made of 10 × 10in. pine timber. The clear span between the towers was 630ft., and the diameter of the cables 1¾in., steel. The engines were double cylinder 8¼ × 10in., reversible link motion, 30 h.-p., with large drums for high speed. One 40 h.-p. boiler supplied steam for both. A very important part of the work assigned to the cableways was the removal of the old bridge piers, etc., and the removal of about 5,000 cubic yards of rock from the bed of the river, and at the abutments. The cableway, being over-

head, was well adapted for this work, as it was out of the way of the blast.

The last illustration depicts a semi-portable cableway used at Orange, N.J., for sewer excavation. With a single bucket and in good digging this cableway easily handled 220 yards per day, averaging 44 loads per hour, and, for a single hour, has frequently handled 60 loads. The problem of rapid and economical trench excavation seems to have been solved by this type of cableway. The whole apparatus can be taken down, moved ahead, and re-erected in a few hours with very little expense.



NEW MACHINERY, APPLIANCES, ETC.

(Manufacturers are invited to send particulars and illustrations of New Machinery for Notice, free of charge, under this Heading. Although the merits of every machine and appliance are investigated by an expert, the Editor desires it to be understood that in some instances he is dependent to a large extent on the statements of manufacturers.)

50-TON OVERHEAD ELECTRIC TRAVELLER (3 MOTOR).

◆ ◆ ◆

HITHERTO, with regard to transportation in or about works, any contrivance that would lift and carry the required load was considered by most engineers as "good enough," the economy of time and labour being entirely neglected, but now, the new economic conditions engendered by close competition render it incumbent on every progressive engineer to provide in his shops, an efficient method of handling plant and manufactures expeditiously.

Although the obvious advantages of Electricity as a means of conveying power from a stationary to a moving source have always attracted considerable attention from Engineers, it is only within the last few years that electric driving has been adopted in engineering shops to any great extent.

Messrs. Vaughan & Son, of Manchester, were amongst the first to grasp its possibilities with reference to their speciality of manufacture, viz., Overhead Travelling Cranes.

The 50-ton Electric Traveller illustrated herewith, is one of Messrs. Vaughan & Son's latest productions, and is erected in the boiler shop at Messrs. Hick, Hargreaves & Co.'s, Ltd., Works, Bolton. It has a span of 50ft., the girders being constructed of double web mild steel plates. The depth of the girders at their centres being 5ft. Current is conveyed along the gantry to the three switches by two bare copper wires, and collected by means of a sliding contact. The switches are located in the cage slung at one end of the crane girders, and control the three motors. They are so arranged that the operator can manipulate the three motions of the traveller either separately or simultaneously as required. The three reversing motors are series-wound and suitable for continuous current; they were specially designed for this crane, their speeds being variable from zero to their maximum, by simple movements of the respective switch handles. The hoisting and cross traverse motors are incorporated, practically in the crab sides, the reduction of speed being accomplished by means of spur gearing suitable for two speeds of hoisting on each of the two barrels. The longitudinal motor is carried on brackets at the end of girders, and by means of suitable spur gearing and a connecting cross shaft, motion is conveyed to one travelling wheel in each wheel box, thus ensuring smooth running and freedom from "cross-winding."

Any risk in hoisting through want of attention or carelessness, is removed by means of a powerful automatic brake. When current is switched on to the hoisting motor, it puts into circuit an electro-magnet of sufficient power to raise the brake lever, and render it inoperative at the moment when hoisting or lowering commences. The brake lever is "held-up" as long as current is switched on to the hoisting motor, the act of "switching off" immediately, and without any attention whatever on the part of the operator, allows the brake to be instantly applied. The advantage of such an arrangement is obvious, as if through any reason during working operations the current should fail, the brake magnet would instantly release the brake, and allow it to take charge of, and sustain the load. It is fitted with a patented arrangement which enables it to be gradually applied, and, whilst securing effectual control of the load,

prevents any undue shock that might arise through the brake being too suddenly applied.

The speeds at which the 50-ton crane works, are as follows :—

Longitudinal Traverse	200ft. per min.	With light loads or empty.
Cross ,,	100ft. ,,	
Hoisting 50 tons at	1¾ft. per min.	Large barrel.
,, 25 tons at	3½ft. ,,	
,, 7 tons at	12ft. ,,	Small barrel.
,, 3½ tons at	24ft. ,,	

It is, of course, quite possible to use the same generator for both "shop" lighting and the transmission of power. In Messrs. Vaughan and Son's shops, for example, a 30 H.P. Dynamo, 200 amps, 110 volts, worked from the ordinary line of shafting, generates sufficient current for working simultaneously :—

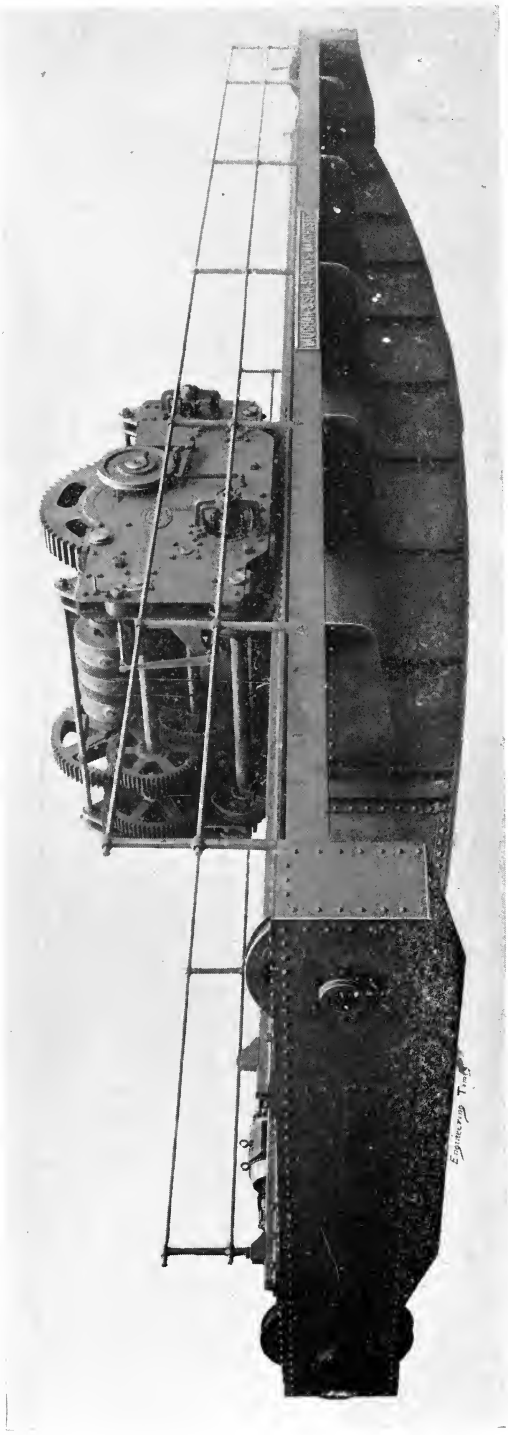
(1.) A 20-ton three motor Electric Crane with full load, and all three motions at once.

(2.) Efficiently lighting the shops by means of a number of arc lamps.

(3.) Working one or two motors in connection with machine tools.

It is a fact that cranes, even in the busiest shops are not actually engaged for more than about ½ of the working hours. The rest of this time is taken up whilst adjusting slings, preparing loads, &c. In a rope-driven crane, the consumption of power is constant, whether the crane is working or not, whilst in an electrically driven crane, assuming the dynamo is driven from the ordinary line of shafting, the belt is, to all intents and purposes, as running on a loose pulley during these periods, and even when working, the strictest proportion between the actual work done and the power consumed is always observed.

In comparing this with a rope-driven crane — where it takes several horse-power to alone keep the rope moving — the high economy must be apparent.



50-TON OVERHEAD ELECTRIC TRAVELLER BY MESSRS. VAUGHAN & SON, MANCHESTER.

The following particulars of a test made on a 5-ton Vaughan's Electric Traveller, span about 30ft. will prove interesting: —

	Load.	Speed per minute	Amps.	Volts	Horse power.
Hoisting	Light	11½ft.	8	100	1·07
,, ...	5½ tons	5½ft.	28½	100	3·8
Cross Traverse ..	5½ tons	85ft.	16	103	2·2
Longitudinal Traverse	Light	300ft.	26	103	3·6
,, ,,	5½ tons	260ft.	38	103	5·2

A. G. P.

THE "ARCHBUTT-DEELEY" PROCESS OF PURIFYING AND SOFTENING WATER.

◆ ◆ ◆

IN a previous issue we dealt in a general way with the subject of softening and purifying the water for boilers, and therefore no introductory remarks on the subject will be necessary before proceeding to describe the "Archbutt-Deeley" process.

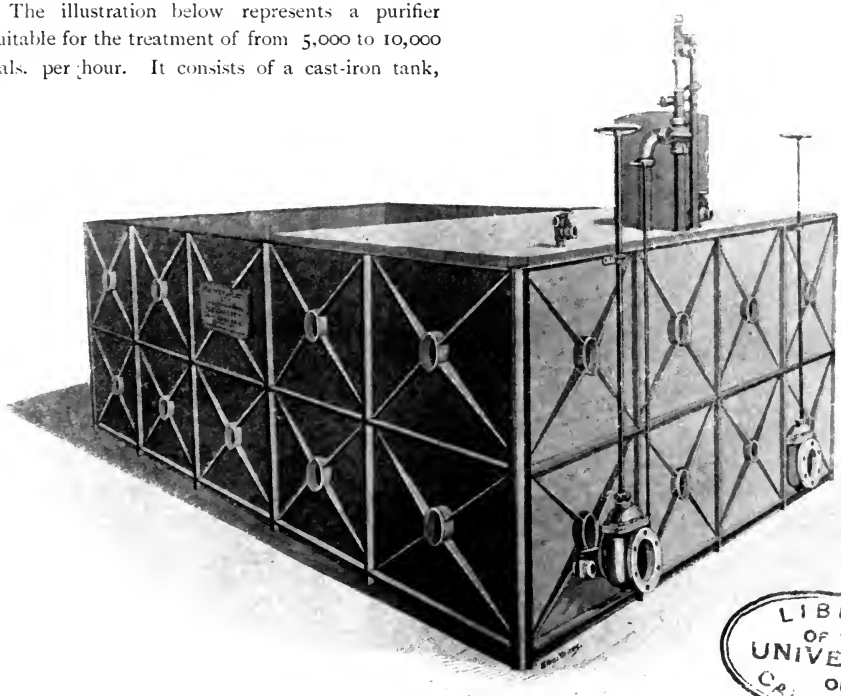
The illustration below represents a purifier suitable for the treatment of from 5,000 to 10,000 gals. per hour. It consists of a cast-iron tank, divided into two equal parts by a transverse partition. The two tanks thus formed are fitted up exactly in the same way, the processes of filling, softening and clarifying being carried on in one, whilst softened and clarified water is being drawn off from the other.

For 3,000 gals. per hour, and less, one softening tank is sufficient if a storage tank is provided, For more than 10,000 gals. per hour three or four tanks are desirable.

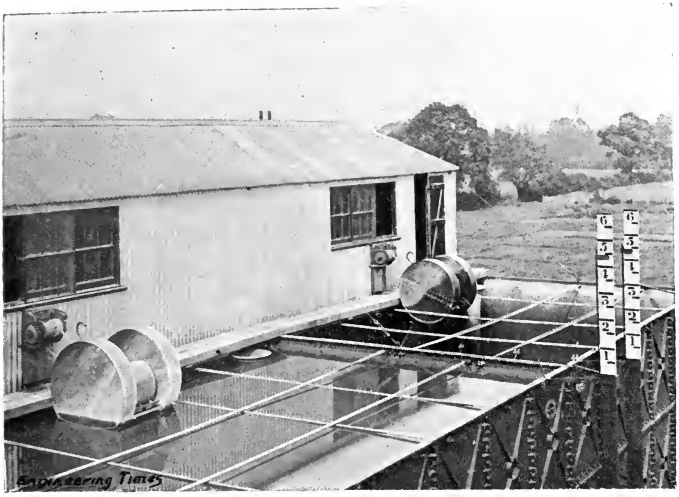
Hard water is admitted to either tank by means of the supply pipe, which is connected up to a pump or main. The water is run in up to the level of a gauge mark on the side of each tank.

While the tank is filling, quicklime and sodium carbonate (58 per cent. alkali), in proportions which depend upon the character of the water, are weighed out, and boiled up with water in the small chemical tank by means of live steam. The lime is first slaked in the hot water, and then the alkali is added and stirred until dissolved.

When the tank is full, and the inlet valve has been closed, steam from the boiler is admitted to the blower, causing a current of water to circulate through the rose, the three-way cock,



ARCHBUTT-DEELEY" WATER SOFTENING APPARATUS.



WATER SOFTENING APPARATUS AT SWADLINCOTE AND ASHBY WATERWORKS: CHEMICAL TREATING HOUSE AND TANKS

down the vertical pipe and back into the tank through the perforations in the *upper* row of horizontal pipes. On opening the small tap the prepared chemical solution is slowly drawn into the circulating current, and thus diffused throughout the body of water in the tank.

The cock is next opened to admit air through the pipe at the top of the blower, and by reversing the three-way cock this air is forced through the perforations on the under side of the *lower* row of pipes. From these it rises in streams of bubbles, stirring up some of the precipitate or mud from previous operations which lies on the bottom of the tank. Before being mixed with this mud, the new precipitate, which is very finely divided, will not coagulate, and takes a long time to settle; but when the old precipitate, consisting of coarse particles, is stirred up the fine particles attach themselves to the coarse particles, and subsidence of the precipitate is thereby greatly accelerated when the water is allowed to rest.

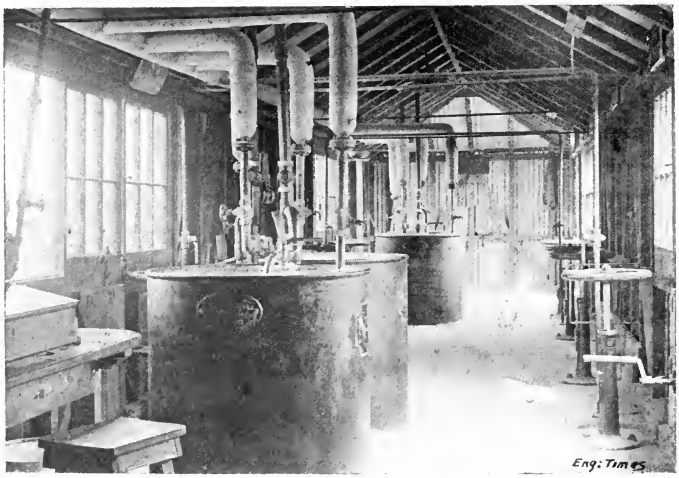
After the blower has been in operation for a few minutes (usually ten, but varying with different waters) the steam is turned off, and in about one hour very nearly all the precipitate will have settled to the bottom of the tank, and the water, even down to a depth of 6ft. from the surface, will not contain, on an average, more than about one grain per gallon of suspended matter.

At this stage of the process the water is tested to ascertain if it has been properly treated. This test is very simple and effective, and is easily made by the man in charge.

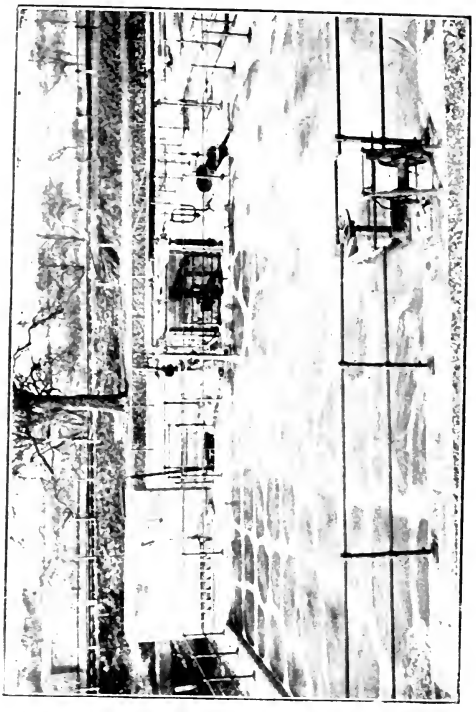
Uncarbonated softened water is liable to form a deposit in pipes, and especially in the feed apparatus of steam boilers, which may become very troublesome. This is not a peculiarity of water softened by our process, but is common to all methods of treatment.

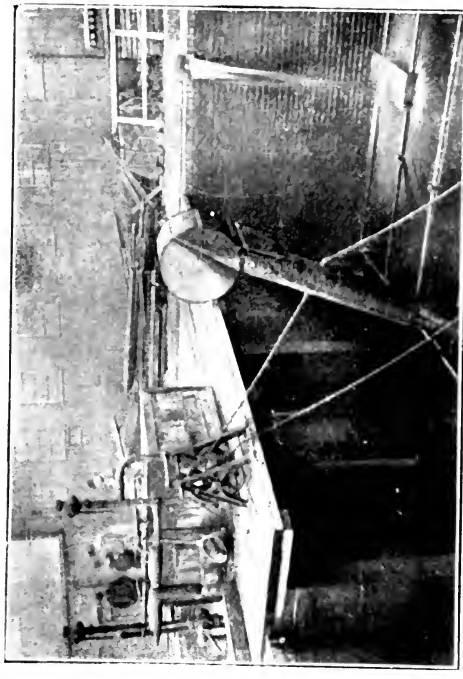
The process of carbonating is extremely simple, and the extra labour and cost involved are inconsiderable, and the operations of carbonating and drawing off are automatically and simultaneously effected.

Experience proves that for boilers, carbonating

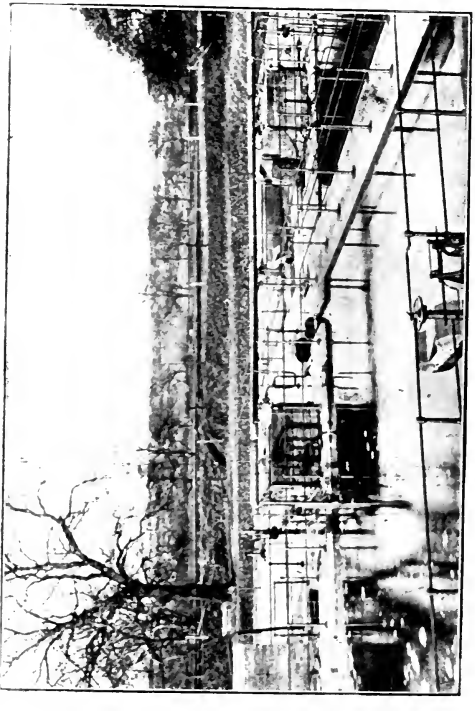


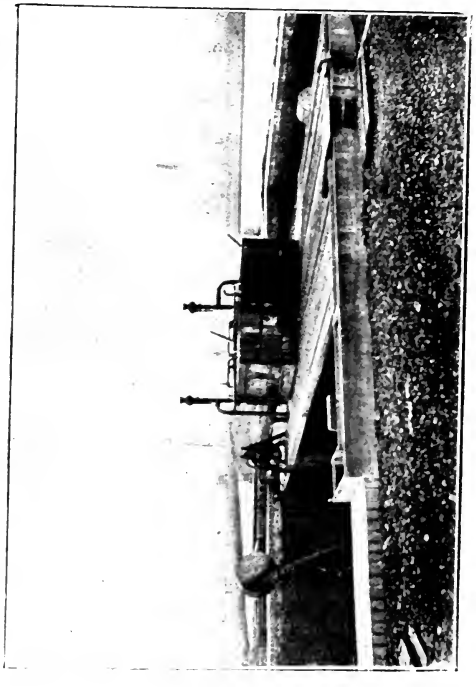
WATER SOFTENING APPARATUS AT SWADLINCOTE AND ASHBY WATER WORKS; CHEMICAL TREATING HOUSE—INTERIOR.





WATER PURIFICATION PLANT, ARCHBUTT & DEELEY'S PATENTS FOR THE TREATMENT OF 120,000 GALLONS PER HOUR.





is not always necessary; and that where it is necessary, occasional carbonating is often sufficient to prevent any trouble from deposit in feed pipes.

The precipitate is prevented from unduly accumulating in the tank, by its partial removal at regular intervals; this is effected in various ways, to suit different circumstances. From the nature of the precipitate it is easily dealt with. In small plants, a discharge pipe is provided in one corner of the tank, and by lifting a plug daily, a sufficient quantity of mud can be run off. In larger plants, the mud is swept out, at longer intervals, through mud doors, into a trough which conveys it on to waste ground; or, it is raised out of the tank or trough by a steam lifter, and discharged into a cart lined with waste furnace ashes, through which the excess of water readily drains, leaving the nearly dry mud and ashes ready for tipping.

That steam boilers, and their feed apparatus and economiser ubes, can be kept quite free frcm scale b the above process of softening the water, ha been amply proved at the works where it has been adopted. A plant softening 30,000 gallons per hour has been in successful and continuous operation at the locomotive works of the Midland Railway Company, at Derby, since 1891. The hardest water at present (1898) being treated is at a mill in Nottingham; it has 35½ deg. of hardness, and contains both carbonate and sulphate of lime, as well as a large quantity of magnesium salts; by this treatment, the hardness of the water is reduced to an average of 3·2 deg., and the formation of boiler scale is entirely prevented.

All the mechanical operations are very simple, and the labour involved is light. So far as labour is concerned it costs little more to soften 20,000 gallons at one time than to soften 2,000 gallons; and where the quantity of water required per day is not large enough to warrant the cost of special labour it is better, where there is room, to erect a plant of greater capacity than is absolutely necessary, because then the number of softenings per day is lessened, and, as each softening takes only a few minutes, the boiler attendant can spare enough time to do what is required.

The softening tanks are also storage tanks—a point to be remembered when considering the space occupied. Existing storage tanks can be fitted up as softening tanks if of suitable size and shape.

The steam used by the blower is only sufficient to raise the temperature of the water about 2 degrees F., and, when the water is required for boilers, more or less of the heat is returned to the boilers, and must not therefore be charged to the softening process; if the whole of it is charged it amounts to very little.

To remove calcium carbonate (carbonate of lime) from water by this process costs very little, because lime alone is necessary, and is very cheap. To remove calcium sulphate (sulphate of lime) alkali must be used, which increases the cost. For the removal of magnesium salts, caustic alkali is required, and the alkali has to be used in greater relative proportion; waters containing much magnesium salts are therefore the most costly to treat, though in this method of softening, the caustic alkali, being made as required by boiling lime and alkali together, is cheaper than if caustic soda were purchased ready prepared. The costliness of softening is, in many cases, a measure of the necessity for softening; and it is often more economical to soften a bad water, which can be had for the pumping, than to purchase a town's water which is itself only less hard than the existing supply.

The makers of the Archbutt-Deeley Apparatus are Messrs. Mather and Platt, Limited, Salford Iron Works, Manchester.

THE "HELICOID" LOCKNUT.

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THE article which appeared in a recent issue on "The Essential Features of a Good Locknut," has brought us a number of enquiries as to where such a nut as there described could be obtained, and we think we could not reply to our correspondents in a better way than by giving them a description of a locknut which, in our opinion, is nearest what a locknut should be than any other with which we are acquainted.

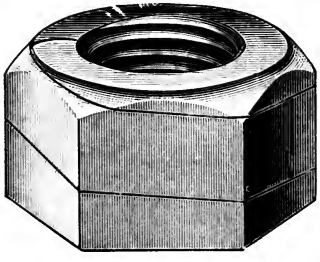
Before proceeding with the description, however, we might quote from the article referred to as to the essentials of a good locknut. It must be easily screwed on to the bolt without any special appliance; it must remain firmly in position when it has once been screwed up, whether tight to the bearing or slack; it must not in any way injure the threads of itself or the bolt in going on or being taken off; it must be easily removable without injuring its locking powers; it must consist only of one piece; it must resemble the ordinary form

of nut with which mechanics are familiar; and must be applicable to all purposes.

Experience has shown that these advantages are to be found in the Helicoid Locknut, which is formed by coiling on a mandril a bar of steel or other suitable metal of special section, in a cold state, in such a manner that a close helical coil is formed. This coil is then sawn into suitable lengths, according to the size of the nut for which it is formed. The blanks are then tapped, faced, shaped as required, chamfered and countersunk at both ends.

In tapping the pitch of the threads are cut the same as the bolt, but the internal diameter of the nut is made slightly smaller than the bolt on which it is intended to be used, so that in placing the nut on the bolt the former of necessity expands, thereby bringing into action the spring of the coil.

The nut can be removed and replaced on the bolt as often as desirable without in any way injuring either the nut or the bolt, or impairing the self-locking powers of the nut.



The nut has the appearance, to all practical intents and purposes, of an ordinary nut. No washer is necessary; in fact there is no accessory of any sort or kind, nor is any special operation required for placing it in position on the bolt, an ordinary spanner being quite sufficient. It is not necessary to screw the nut down particularly hard, as it will remain in the position in which it is placed on the bolt.

The nut, which is manufactured by the Helicoid Locknut Patents Co., Limited, 147, Dashwood House, London, E.C., has been thoroughly tried in practical use by the leading railways and engineering firms, during the last three or four years, and the results have been eminently satisfactory.

NOTES.

We have received a copy of the new oil-engine catalogue of the Campbell Gas Engine Company, Limited, of Halifax. It is a capital production, and the illustrations are particularly striking. It contains every particular concerning the well-known "Campbell" Oil-Engine. The great merit of this engine is its extreme simplicity of construction, its reliability, and easy management. In its manufacture only two valves are used, and these are so simple that any intelligent person can understand their action. We advise those of our readers who are interested in oil-engines to send for a copy. It contains a lot of useful information on the subject.

◆

A sample of Boiler Covering from Messrs. Lawson Brothers and Co., of Marsh Works, Bristol, has reached us. The makers claim that this covering is equal to slagwool, magnesia or asbestos; that it possesses great tenacity, adhering firmly to iron or metal. It is fibrous, tough, non-combustible and impervious to frost, and, further—and what is an important consideration—it is cheap, as one ton will cover 400 superficial square feet 2in. thick. Judging from the testimony which Messrs. Maudslay Sons and Field, Messrs. J. Lysaght, Limited, and others have borne as to its merits, it would seem that the makers are not claiming too much for their product.

◆

The report of Robey and Co. (Ltd.) for 1898 states that, after writing off £6,080 for depreciation, the net profit was £30,563. After deducting debenture interest, and adding £770 brought forward, there is a balance of £24,147 available for division. The directors recommend a dividend of 10s. per share, and the adding of £10,000 to the reserve, carrying forward £352. The directors have resolved to pay off during the present year the whole of the second issue of debentures, amounting to £46,305.

◆

Messrs. J. and H. Gwynne, Limited, Hammersmith Ironworks, have commenced the erection of a new foundry, and when completed their present foundry will be converted into a fitting shop. The company's works are on the Thames Bank, close to Hammersmith Bridge, and the river frontage has lately been increased 195ft. by the purchase of adjoining land.

AN HOUR AT THE PATENT OFFICE.

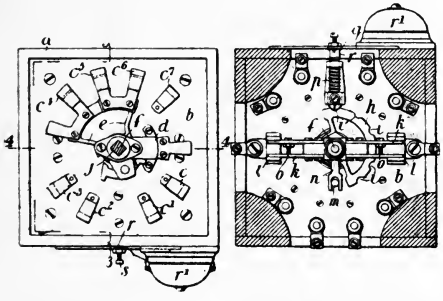
◆ ◆ ◆

(Selections from recently published patent specifications. Complete copies may be obtained at the Patent Office Sale Branch, 25, Southampton Buildings, Chancery Lane, E.C. Price 8d. each.)

No. 3,555 of 1898, C. P. Elieson, of West Kensington, and W. S. Naylor, of Camden Town, for "A combined switch and controller for electro motors."

With this combined switch and controller, the speed of electro motors, particularly in the case of electrically-propelled vehicles, boats, and the like, can be controlled and regulated in a more simple and certain manner than hitherto.

That part of the shaft *f* upon which the contact arm *d* is mounted, is made of square section as indicated at *j*, and we make the boss of the arm *d* of a corresponding shape so that the said part *j* is free to slide therein. It is to be understood, however, that the part *j* may be of any desirable shape, or, if desired, a key working in a key-way may be made use of, provided that the shaft *f* is free to slide up and down, and is also able to transmit the rotary movement to the contact arm *d*.



To the lower end of the said shaft *f*, a contact bar *k* is fixed, the said bar being insulated from the said shaft, and on the underside of the plate *b* are fixed two contact forks *l*, *l* which contact forks together with the bar *k*, are designed to form a part of one of the current leads to the motor, whereby it will be readily understood that when the bar *k* is in its upper position, this part of the circuit of the motor will be intact, whilst when the shaft *f* is depressed so that the bar *k* occupies the lower position, the circuit will be broken; that is to say, so long as the bar *k* is in contact with the forks *l*, *l*, the current can be distributed by the contact arms *d* and *e* in any desired manner by rotating the shaft *f*, whilst when the said bar is lowered out of contact with the forks *l*, *l*, the circuit is broken, notwithstanding that the circuit is closed in so far as the contact arms, *d* and *e*, are concerned.

The operation of this contact arrangement is as follows:—Suppose that the circuit is completed through the bar *k*, and that the contact arm *d* is in contact with the contact piece c^3, which corresponds with the fastest speed of the motor; if now it is desired to suddenly shut off the current it is only necessary to depress the shaft *f* so as to move the bar *k* out of contact with the forks *l*, *l*, whereas hitherto it has been necessary to turn the arm *d* back to its zero position past all the contacts c^2, c^1, and *c*, thereby causing an amount of sparking which would rapidly cause the deterioration of the said contents. When, however, the contact is broken by the bar *k*, the contact arm *d* can be turned back to its zero position without any sparking at all, so as to be again ready for starting the motor at the slowest, or any intermediate speed as desired. By this construction it will be understood that practically the whole of the sparking, if the contacts *k*, *l* are properly used, will take place on these contacts, which can be readily renewed, instead of upon the main contacts.

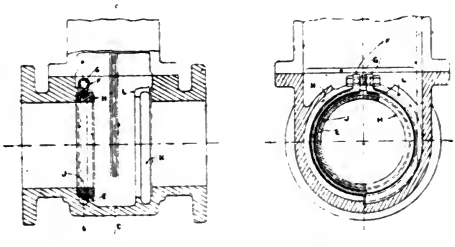
(*m*). Is a guide bar fixed to the plate *b*, and having engaging with it the forked end of a guide arm *n* fixed to the side of the bar *k*, the said guide bar and guide arm serving to maintain the said bar *k* with its ends in proper position relatively with the contact forks *l*, *l* during the turning of the shaft *f*; *o*, *o* are adjusting screws for regulating the friction between the ends of the bar *k* and the surfaces of the contact forks *l*, *l*.

In order to indicate to the driver of a motor when the contact arms d and e are in full contact with their respective contacts c, c^1, c^2, c^3, c^4, c^5, c^6, c^7, the spring pin p is used, which operates in conjunction with the notches i, i of the segment h in a well-known manner. An insulating button q on the outer end of the spring pin p is arranged in conjunction with a contact spring r in the circuit of an electric bell r^1 and battery; so long as the pin p is in full engagement with one of the notches i, i, the contact between the spring r and the corresponding fixed contact s is broken. Should, however, the segment h, which rotates with the spindle f, stop in such a position that the pin p is out of engagement, or only partially in engagement with one of the notches i, then the said pin will hold the contact spring r against the contact s, and close the circuit so that the bell will ring; that is to say, when the contact arm d is not in full contact with one of the contacts c, c^1, c^2, c^3, the bell will indicate this by ringing.

◆ ◆ ◆

No. 6,679, of 1898, W. Marchant, of Ashton-under-Lyne, for "Improvements in and relating to Valve Seats."

The improvements refer to the various types of valves used for the purposes of steam, water, gas, or other uses, in which the valve seating forms a separate part from the valve body. Hitherto, such seatings have usually been either pressed into a recess provided in the valve body or screwed into a similar tapped recess in the said body.



In practice such methods have given considerable trouble after a brief period of work, by reason of the seatings so secured becoming loose and leaky, and rendering the valve ineffective thereby. In such cases it has proved either impossible to remove a seating so secured, or a task of great difficulty, and expenditure of time. This invention obviates these defects, a more reliable action of the valve is obtained, and increased facilities are provided for repairs or renewal of the seatings. To attain these objects, the usual annular seating ring is employed of either angular, rectangular, or other section to suit varying conditions and types of valves.

In the periphery of this seating ring a tapered groove or channel is formed around its whole circumference, opposite this a similar but wider groove is cast in the valve body, and next which the seating ring circumference rests; this groove may be continuous or intermittent, in the shape of cast grooved lugs, as may be found most suitable to conditions. Placed within the valve body groove is a circular metal clip ring, made in any suitable section or material, and formed in one piece or any requisite number of segments, provided with necessary bolting ears or the like, by means of which it is drawn together and secured. In this tightening operation, one side of the ring is drawn in contact with the side of groove cast in valve body whilst the opposite side of clip ring is pressed against the seating ring taper groove side next the valve inlet.

The contacts thus made between the clip ring and edges of both grooves extend practically round the whole outer circumference of seating ring. Owing to the edges of these two grooves overlapping slightly a space is formed which allows the clip to pass into the seating ring channel in the tightening operation, and in so doing it forces the seating ring upon its bed.

Fig. 1 is a sectional elevation of an 8in. steam junction valve, and Fig. 2 is a plan in section on line A, B, also a part plan section on line C, D showing the interior of the clip ring grooves in both the valve body and the seating ring rim as applied to this type of valve. E is the clip ring, F the bolting ears to force and hold the seating ring H on its bed or seat, G the compression bolt, J the seating ring groove, and the K the ring groove in the valve body.

The seating and clip ring are applied to a valve in the following manner:—

Compress the clip ring E until it will pass into the groove K, next insert the seating ring H in position, bolt the clip ring E together and tighten the seating as required.

To release the seating H, and ring E, unbolt the clip ring E, wedge open the ears F sufficiently to allow the seating

ring H to pass out through the clip ring E, then withdraw the wedge and compress the clip ring E sufficiently to let it pass out of the groove lip L.

In small valves the clip ring E may be applied in the form of a split spring ring and hold the seating by spring compression instead of by means of a bolt.

The specification also shows the invention applied to an 8in. clearway stop valve.

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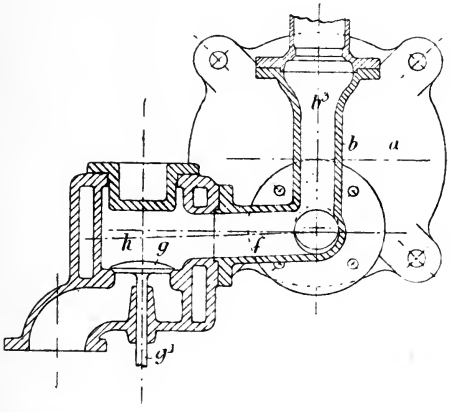
No. 8,039 of 1898, S. B. Bamford, of Uttoxeter, for "Improvements in Explosion Engines."

This invention has for its object to simplify and improve the construction of oil engines working on the "Otto" or "four-stroke cycle" principle, and to improve the means for governing and regulating the speed of oil or gas engines.

Fig. 1 is a sectional view of the rear end of an engine cylinder having an improved vaporizer applied to it; and

Fig. 2 is a section partly on the line 3-3, and partly on the line 3^*-3, Fig. 1.

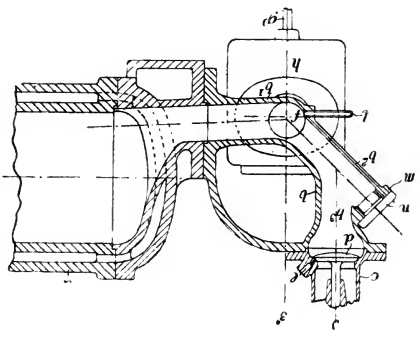
(*a*). Indicates the engine cylinder, which is provided with a cooling jacket in the usual manner, and *b* is a vaporizer, which is attached to the end of the cylinder, and



which carries a valve box, *c*, containing a valve, *d*, which serves to control the admission of air through the valve box, and of liquid hydrocarbon through the nozzle, *e*, the said valve opening automatically by reason of the suction produced during the outstroke of the piston in a well-known manner.

(*f*). Is a branch pipe upon the vaporizer for the escape of the exhaust gases, and *g* is the exhaust valve, arranged in a chamber, *h*, which is preferably provided with a cooling jacket, and which chamber is connected with the exhaust pipe by a flange joint. The valve, *g*, is operated by means of a cam on the usual side shaft of the engine through the medium of a lever against a roller, at one end of which the cam acts, and the other end of which is in contact with the stem g^1 of the exhaust valve *g*.

(*l*). Is an igniting tube attached to the vaporizer *b*, which igniting tube can be heated by a lamp for starting the engine, and its use then discontinued; or if the



heat generated by the explosion is found insufficient to maintain the heat of the vaporizer after starting the engine, the use of the said lamp may be continued.

In the arrangement shown the vaporizer is formed with a horizontal portion, b^1, with a portion, b^2, inclined upwards at an angle of about 45 degrees, and with the vertical portion, b^3, the top of which vertical portion carries the valve box *c* containing the valve *d*. The inclined portion, b^2, is formed with an extension, *m*, provided at the end with a plug or screw, *n*, the removal of which serves to afford access to the interior of the vaporizer for the purpose of cleaning out the same, if necessary.

It will be noticed that the branch *f* through which the exhaust gases pass, being placed at an angle with the vaporiser *b*, the exhaust gases as they escape from the cylinder impinge against the walls at the lower end of the vaporiser so as to maintain the heat thereof in such a manner as to ensure the whole of the oil charges being vaporised, and at the return stroke of the piston (when the gases are compressed), ignited.

It will also be noticed, that the communication between the vaporiser and the

cylinder is at the lower part of the latter, and that a slight fall is given to the passage from the lowest point of the cylinder to the exhaust valve, whereby any sediment or the like in the cylinder will be carried out by the gases of combustion through the exhaust valve.

Modifications of the invention are shown and described.

The governor for controlling the speed of oil and gas engines has centrifugal balls with arms pivoted in projecting lugs in the usual way on the rising head and having a removable weight on the top; the rising head has a groove in which is fitted a collar pivoted to a fork lever working on a centre, the opposite end of the fork lever is connected by a vertical rod fitted with a spiral spring to the horizontal end of a bell crank lever, the lower end of which forms a stop to the lever arm which opens the exhaust valve.

When the engine speed accelerates, and the governor balls rise, the fork lever communicates a downward motion to the horizontal arm of the bell crank lever, whereby, when the lever arm of the exhaust valve is pressed downwards by the cam on the side shaft for the purpose of opening the exhaust valve, the lower end of the bell crank lever is moved laterally by the action of the governor, and comes into contact with a catch placed on the exhaust lever arm, thus holding open the exhaust valve. The governor, owing to the spiral spring, has liberty to fall when the speed of the engine is reduced, and when the exhaust lever is again pressed by the action of the cam on the side shaft, the spring on the vertical rod instantly removes the bell crank lever away from the catch on the exhaust lever arm, thus again allowing the exhaust valve to be closed at the proper time for the next charge.

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No. 1036 of 1899, J. Vogt, of Massevaux, Germany, for "Improvements in apparatus for deep boring."

This invention relates to improvements in apparatus for boring at great depths, in which the boring tool or cutter is rigidly connected to the bore rod, which is actuated by a rocking beam.

The improvements are described by way of example as applied to a construction of boring apparatus, similar to that described in the Specification to Patent No. 30,024, of December 18th, 1897, in which springs are interposed between the bore rod and the actuating beam, as also between this and the driving connecting rod.

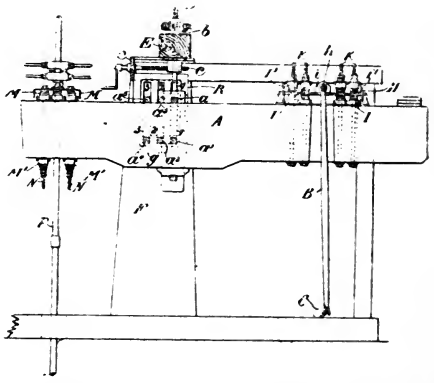
Figs. 1 and 2 show respectively a side view and a front view of the apparatus, both views being partly in section.

Figs. 3 and 4 show to a larger scale detail views of parts of the apparatus.

The oscillating beam A, which raises the bore rod P, is actuated by the connecting rod B, receiving its motion from the crankshaft C. The trunnions a of the beam are suspended by means of two screws D, D held by screw nuts b, carried by the sliding support E, which can be shifted horizontally upon the uprights F, by means of a horizontal screw spindle c, carried in a plate e, fixed to the uprights F.

The screw nuts b are formed as worm wheels at their periphery, and gear with a worm f.

To the uprights F are fixed plates R, having vertical grooves, 1, 1, 2, 2, 3, 3, communicating at bottom with a horizontal



groove g, and the ends of the trunnions a of the beam are provided with blocks g^1 which are adapted to slide in one or other of the grooves 1, 2, or 3, into which they may be brought by first shifting them along the horizontal groove g by means of the screw c, and then raising them in the required vertical groove by means of the worm f, which actuates the nuts b of the suspension screws D.

Thus assuming the trunnions a of the beam to be in the position shown in full lines then on turning the worm f they may be brought to the position a^1, and on then turning the screw c they can be brought either into the position a^2 or into the position a^4; on then again turning the

worm *f* the trunnions of the beam can be brought either to the position a^3 or into the positon a^5, these several positions of *a* being indicated in dotted lines.

It will be seen from the above description that in shifting the trunnions *a* of the beam from the grooves 1, 1, of the uprights F to the grooves 2, 2 or 3, 3 (the trunnions having previously been disconnected from the beam in any suitable manner), the stroke of the bore rod P will be diminished, while if the trunnions *a* be shifted from the grooves 3, 3 to the grooves 2, 2 or 1, 1 the stroke of the bore rod P will be increased, so that by this means the action of the boring apparatus can be adapted to suit strata of different hardness through which the boring has to be made, without requiring to replace the crank shaft C by another for imparting to the connecting rod a different length of stroke, which operation would cause a considerable loss of time.

When diminishing the stroke of the bore rod, its speed can be increased.

The pivot *h* of the connecting rod B is fixed in a bearing *i*, fixed on a plate H, resting on the springs I, which, as described in the said specification No. 30,024 of 1897, have for their object to deaden the shocks which the connecting rod tends to impart to the beam on starting the upward motion of the bore rod. On the plate H rest counter springs I^1, and the tension of these springs I and I^1 can be regulated by means of screw bolts and nuts K. The counter springs have for their object to deaden the shocks which the beam A tends to transmit to the rod B on the downward or percussive motion of the bore rod P. Their tension can be regulated by means of the bolts K according to the weight of the bore rod, that is to say, according to depth at which the boring tool fixed to the bore rod is acting.

The springs M, on which rests the bore rod P, and which, as described in Specification No. 30,024 of 1897, have the object of deadening the shocks which the bore rod tends to impart to the beam A at the free fall of the former, are also combined with counter springs M^1 placed beneath the beam A, and the tension of these springs MM^1 can be regulated, according to the weight of the bore rod, by means of screw bolts and nuts N. The springs M^1 prevent any sudden upward jerks of the bore rod when it is being raised.

By thus deadening the several shocks to which the apparatus is liable, any damage to the bore rod is prevented, and the speed of working can be increased.

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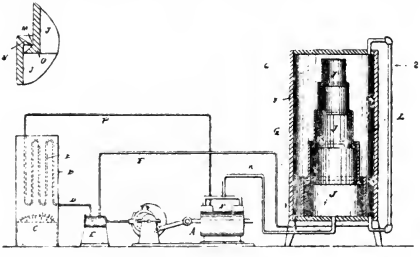
No. 1666 of 1899, L. B. White, of New York, for "Improvements in Condensing Motors."

For many years attempts have been made to operate motors by means of liquefied carbonic acid gas or liquefied carbon dioxide, but the cost of the liquid carbon dioxide is too great to render the use of such motors economical under all circumstances, and for that reason numerous attempts have been made to regain and liquefy the spent or exhaust carbon dioxide, but such attempts were not successful commercially, as the cost of condensing or liquefying such spent gases was too great.

The object of this invention is to provide a new and improved motor, to be operated by means of liquid carbon dioxide, and in which the liquid carbon dioxide is heated



for the purpose of increasing its tension; and, after the high tension gas has worked the motor, the spent gases are condensed and liquefied and then pumped into the heater to be again increased in tension, and so on.

The liquid carbon dioxide is heated in the heater B, and its tension is raised to a pressure of from 2,500 to 3,000 lb. per square inch—that is to say, by the action of the heat, it is converted into a gas of such high pressure, and this high pressure gas, acting on the piston or pistons of the engine A, operates the latter and the spent carbon dioxide gas, which escapes at a pressure of about 250 lb. per square inch, passes or is forced from the valve chamber of the engine through the pipe K into the inner or telescopic chamber of the condenser G, and, as it is still under this comparatively high pressure, it has an extremely

great tendency to escape from the telescopic sections or chamber. Its only way of escape is through the fine annular apertures or slots M, and, in escaping through these fine apertures or slots, the gas expands to an extremely great extent in the chamber H, in which there is no pressure, and in so expanding intense cold is produced and the carbon dioxide at once congeals into flakes resembling snowflakes or hail, which flakes collect in the bottom of the chamber H and there melt, as the bottom and sides of the chamber H are in contact with the outer air, which is much warmer than the interior of the vessel H.

The liquefied carbon dioxide flows from the chamber H through the pipe F, and is pumped by the small pump E from the pipe F into the heater B, and is again brought to a high tension, operates the engine A, escapes into the condenser, etc.

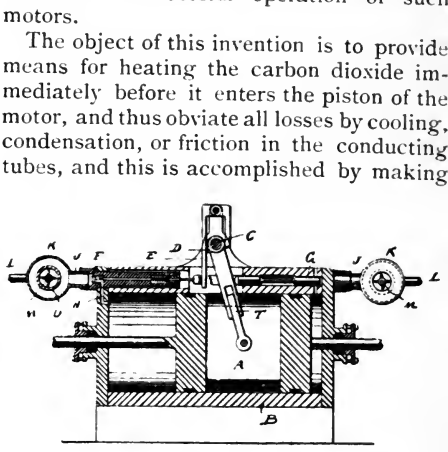
The inventor is well aware that the only source of power in his improved motor is fuel consumed in the burner, in the heater, and that the carbon dioxide only serves as a medium for utilising this power in the most economical manner and to the greatest advantage. Of the heat units in the flame at the burner, a certain amount are used for operating the engine and a certain amount are consumed in the expansion of the carbon dioxide in the condenser, and the reason that the improved motor is so effective and economical is that the proportion of heat units lost in the heater is exceedingly small, as the carbon dioxide has an extraordinarily great affinity for heat and takes up almost all the heat units and further, the proportion of heat units consumed in the expansion of the gas for congealing it is very small in proportion to the heat units consumed in producing the power in the engine; or, in other words, of all the heat units representing power, taken up by the liquid carbon dioxide from the heater flame, the greater proportion is consumed in operating the engine, and the small balance is consumed in congealing the liquid carbon dioxide, which is thus brought into its original condition ready for taking up new heat units in the heater.

From the effective power of the engine the power for operating the pump must be deducted in the same manner that the power for operating the pumps of a condensing steam engine must be deducted from the effective power of such engine.

No. 1,668, of 1899, L. B. White, of New York, for "Improvements in Carbon Dioxide Motors."

Heretofore carbon dioxide motors have been operated by carbon dioxide under high pressure, and attempts have also been made to heat the carbon dioxide before it enters the motor for the purpose of increasing the pressure, and, in consequence thereof, the effective work of the motor, but mechanical difficulties presented themselves which prevented the successful operation of such motors.

The object of this invention is to provide means for heating the carbon dioxide immediately before it enters the piston of the motor, and thus obviate all losses by cooling, condensation, or friction in the conducting tubes, and this is accomplished by making



the heater a part of the chamber for supplying the carbon dioxide to the motor and by locating this chamber and heater in close proximity or adjacent to the valve chambers of the motor.

The double piston A in the cylinder B works the rock shaft C, which carries cams D, that actuate the pivoted arms E, which in turn act on the ends of the stems of the inlet valves F, and the exhaust valves G are operated by the lever T.

When the inlet valve F is open, the channel H is open, and communication is established between the interior of the cylinder B and the short neck J, which is attached to the chamber K containing the carbon dioxide to be admitted to the cylinder for operating the motor.

The carbon dioxide is conducted into this chamber through a suitable supply pipe L.

A suitable burner M of any desired kind is provided for heating this chamber and the carbon dioxide therein, and it is preferred to give this chamber an annular shape in cross section, that is, to place an inner tube O into the chamber K, which inner tube O at its ends is open to the air, whereas the space between the inner tube O and the

chamber K is closed at the ends, to complete and close the chamber, and the burner M for heating the carbon dioxide in the chamber is preferably located within said inner tube O, for the purpose of preventing any loss of heat and for heating the carbon dioxide rapidly.

The heated gas, the pressure of which has been increased, passes from the said chamber directly into the cylinder, and thus all loss of pressure and power by condensation, cooling, or friction is avoided.

It is evident that any type of carbon dioxide motor may be used in connection with the heating chamber, located adjacent to the inlet ends of the cylinder.

As the heated carbon dioxide must be admitted into each end of the cylinder alternately, a heating chamber is provided for each end of the cylinder.

ENGINEERING LITERATURE.

MECHANICS APPLIED TO ENGINEERING. By John Goodman, Wh. Sch., A.M.I.C.E., M.I.M.E. London: Longmans, Green and Co. Price 7s. 6d.

This is a work written expressly for engineers and students who have a fair knowledge of theoretical mechanics and elementary mathematics, to assist them in applying their knowledge to engineering problems. The task which the author set himself was by no means an easy one, and it has been performed with a thoroughness which is decidedly creditable. The reasoning is unmistakably clear, and the work on the whole characteristically concise. Mensuration, Moments, Resolutions of Forces, Mechanisms, Dynamics of the Steam Engine, Friction, Stress, Strain, and Elasticity, Structures and Hydraulics, are a few of the headings to chapters in this valuable book, which runs into some 600 pages, and contains over 600 illustrations. To those intending to enter examinations for the Associate Membership of the Institution of Civil Engineers, the B.Sc. and B.A. degrees in engineering that are conferred by some of the British Universities and the Advanced and Honour's Stages of the Science and Art Department in Applied Mechanics and Machine Construction, this work will be found of real assistance. It is the best work of its kind available.

A HANDBOOK FOR STEAM USERS. By M. Powis Bale, M.I.M.E., A.M.I.C.E. London: Longmans, Green and Co. Price, 2s. 6d.

A sixth edition of this little work has just been issued. It is a deservedly popular book, and should be in the hands of everyone having engines and boilers under their care. It is pregnant with useful hints, which are so arranged under large type headings as to be easily referred to individually. The author has a way of speaking "to the point." There is an introduction devoted to the selection of an engine and boiler, from which we take the following: — "In selecting a boiler, of whatever type, the chief points to consider are: (1) the quality of the feed-water, (2) the quality of the fuel, (3) the cost of the fuel. . . . In selecting an engine the chief points to be borne in mind are: (1) the nature of the work it has to do, (2) the speed and power required, (3) the cost of fuel, and (4) if under skilled management." This is a concise style, which appeals to practical engineers. "Rules for Engine Drivers and Boiler Attendants," "Management of Steam Engines and Boilers," "Explosion of Steam Boilers" and "Advice to Boiler Attendants" are samples of the titles of chapters.

The
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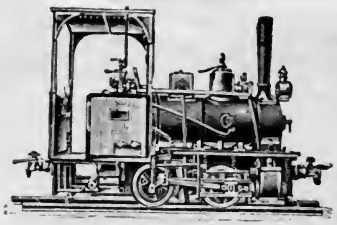

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