LeadNews

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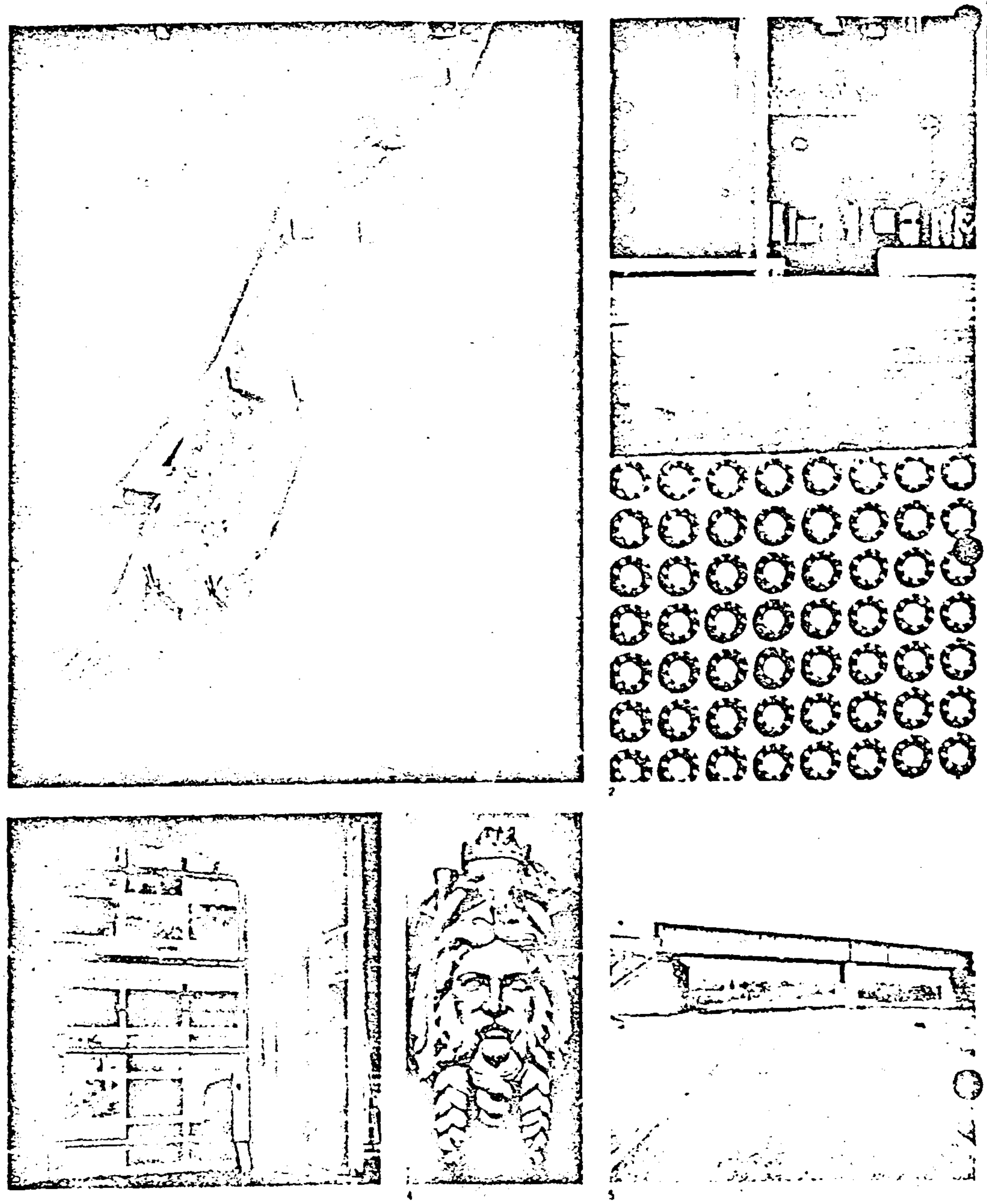


Here and there

Arnhem—International Conference on Lead

The Second International Conference on Lead is to take place at Arnhem in Holland on the 4-7 October 1965. The first conference, which was held in London in 1962, was very successful and there can be little doubt that the second will be equally so. The technical sessions and works visits are being arranged in three groups—cable sheathing, lead-acid batteries, and general applications of lead. Full particulars can be obtained from the Lead Development Association, which is organizing the conference on behalf of the European Lead Development Committee.

Glasgow—Lead keels for yachts

Yacht builders on the Clyde and elsewhere are meeting the growing popular demand for craft of both 'class' and special designs with more advanced methods of building than those used in the past. The designer wants keels of accurate weight in a shape that can be faired cleanly to the hull with a high standard of finish. The yard requires a casting that arrives as nearly as possible ready for assembly and so requires no costly labour in finishing and bolt hole drilling. By using up-to-date foundry techniques, lead manufacturers can ensure that in both keels produced as repetition castings or as a one-off sand castings, the finish, shape and dimensional and weight tolerances will satisfy both the designer and the builder.

To get good control over the weight of the casting, the metal used is of known composition, and is fed to the moulds by techniques that ensure that there are no voids or other faults, which could effect not only the weight but also the centre of gravity. For some designs antimonial lead alloy is specified [illegible] gives a harder face for craft that may be frequently beached.

Accurate repetition of lead keels in batches for 'class' design yachts is best achieved by using metal moulds. The die is prepared in close collaboration with the yacht builder both to determine the place of cast-in holding-down bolts, which are positioned by a jig, and to arrange for the lifting attachments required to facilitate handling the weight. In the case of fibre-glass hulls it is particularly important that the dimensions of the keel and of the hull should be subject to close tolerances. With these hulls designers incline more and more to house the ballast keel within the fibre-glass skin, usually by creating compartments to take shaped lead blocks. This makes accuracy of shape and control of weight more important than ever, and the incorporation of suitable handling facilities in the cast block can contribute greatly to the ease of assembly.

For the 'class' boat, the initial cost of a lead die cast keel is more than off-set by economies at the yard in bolt-hole drilling, handling and finishing, as well as by the superior quality of the final product. Fig. 1 shows one of a batch of keels made by Alexander, Ferguson & Co. Ltd. of Glasgow for the Seamaster 28 Ranger class.

London—Hook, Line and Sinker

A new restaurant in Baker Street, London is called the Hook, Line and Sinker. It has a marked individuality in that architects Leonard Manasseh & Partners have used decorative motives throughout that are derived from the fishermens' gear implied in the name. These include brightly coloured floats mounted on a teak panel on one of the walls and fishing flies behind acrylic resin lenses on another. The bar front is ornamented with cast lead sinkers (see Fig. 2). For this purpose the lead sinkers are no less effective than in their normal role, which is one of the many applications of lead where weight in a compact form and ease of working commend its use.

London—Lead-lined doors at the TV Centre

A double-decker bus could be driven into the BBC's number 1 TV studio at the White City in London through the power operated doors about 18 ft. high by 15 ft. wide provided to give access for large objects.

Doors are, all too commonly, a weak spot in the sound insulation afforded by walls, but these doors are designed to be an effective barrier against extraneous noises, which must of course be kept out of the studio when it is in use. In the construction of the doors there are two characteristics of particular significance in attaining a high standard of sound insulation. Firstly, the edges are designed so that they are well sealed when the doors are closed, leaving no air-gaps through which noise could easily pass. Secondly, a layer of lead sheet is incorporated into the 4 in. thickness of the doors. Lead, because of its mass and limpness, provides a more effective barrier to air-borne sound than a comparable thickness of weight of any other sheet material in general use (see Fig. 3).

Newcastle—River-god Tyne

The wood carving shown in Fig. 4 has quite a history in which lead paint has played a certain though somewhat minor part. The head, with its beard in three plaits, surmounted by a basket containing coals and surrounded by various emblems of the traditional trades of the district, represents the River-god Tyne. It has its origin in a group of nine masks, carved in stone, used to ornament the Strand elevation of Somerset House in London when it was rebuilt in 1786, where a central mask represents the Ocean, flanked by eight others representing the English rivers: Thames, Mersey, Humber, Tweed, Medway, Dee, Severn and Tyne.

An engraving of the Tyne mask was used as a frontispiece to Brand's History of Newcastle upon Tyne, published in 1789; then in 1832 a Newcastle printer and bookseller, wishing to revive the traditional practice of having a sign over the door of his shop, had a wood carving made from the engraving for this purpose—he also used a wood engraving of the head as a printer's colophon. Subsequently the carving passed into the hands of Andrew Reid the founder of a well-known Newcastle printing firm, and it adorned his company's premises until recently when it was withdrawn into the reception room of the company's successors, Hindson and Andrew Reid Ltd.

During its lifetime of about 130 years' exposure the mask had been well coated with lead paint for protection, and when stripped of the dirt, grime and paint down to the bare wood, it emerged in excellent condition. Lead paint does indeed give lasting protection.

Leicester—Red lead paint for motorway bridge

In the face of many changes that have taken place in paint technology in recent years, white lead and red lead remain important pigments, particularly for priming paints formulated to give a good foundation to protective paint coatings. The rust inhibiting properties that are inherent in red lead paints meet many needs today as in the past in protecting steelwork. For example, the steel railway bridge shown in Fig. 5, which crosses the M1 motorway extension near Leicester, has been primed with red lead paint. (Photograph supplied by British Rail, Chief Civil Engineer, London Midland Region.)

Gateshead—Battery power plus radio control

More and more battery-powered industrial trucks are being used in Great Britain for clean and efficient mechanical handling. With a spectacular growth in the number in use and in the variety of purposes they serve, it is not surprising that refinements such as radio control are being introduced for fleets of trucks operating over relatively large areas. The truck driver can be called up by the control room at any time, and be directed to his next job without having to report back to a central point. This saves time, increases efficiency in operating the trucks and, of course, cuts costs. Huwood Mining Ltd, Gateshead operate ten Stacatruc fork-lift trucks and two Electricars by this means and estimate that it makes a saving in drivers' time of about 1½ hours per truck for each 8-hour shift (see Fig. 6).

Stafford—Automatic methane detector

Also connecting lead-acid batteries with mining is the automatic methane detector manufactured by the English Electric Company at Stafford, which has been specially approved by the Ministry of Power for use in coal mines—see Fig. 7. Being completely automatic, the detector can be used by untrained operatives. It measures the amount of methane in the air from the rise in temperature caused by chemical action between the gas and a catalyst which is coated on to a thermocouple. A visual alarm is also provided that lights up when the concentration of methane in the air exceeds a pre-determined proportion.

The weight of the device, including its lead-acid battery power pack, is only 4 lb. The battery has a lightweight polystyrene case, specially designed unspillable filler caps, and gives 4 volts for 9 hours before needing a recharge.

Stoke-on-Trent—Power to a steelworks

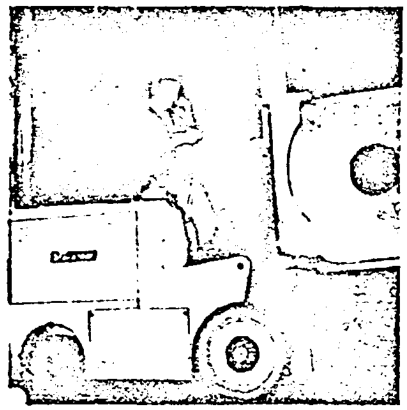
One of the most advanced steelworks in the world, the Stoke-on-Trent works of Shelton Iron and Steel now includes the most up-to-date methods of oxygen steelmaking and a new continuous casting plant. The four machines of this plant—the first to supersede completely a conventional cogging mill—and the reheat furnaces are all housed in one building 500 by 600 ft. There is also a new 900 by 160 ft. building for the main universal and structural rolling mill—the first fully automatic mill of its kind in the UK, and three bays, each about 100 ft. wide and of varying lengths, for three independently driven stands at the finishing end of the mill.

The power supply system from two works substations, which was installed by British Insulated Callender's Cables Ltd., incorporates an 11 kV ring main—a lead-sheathed cable 5,000 yds in length, and a similar feed cable of over 1,500 yds. Fig. 8 shows 11 kV 3-core cables and others in the motor room basement. The loops in the cables are formed where they cross expansion joints in the structure to allow for the possibility of uneven building settlement.

Singapore—Underwater telephone link

A lead-sheathed submarine telephone cable, in one length 8,000 yds long, has been shipped from the UK for an underwater link between the islands of Singapore and Pulau Bukom (Freshwater Island). Essential in the construction of such a cable is a sound and reliable barrier to the ingress of moisture, and this is the main function of the lead-sheathing. A special requirement was the protection of the cable against the risk of attack by the teredo—a small marine animal—and this was done with an outer wrapping of copper tape and double wire armouring served with compounded jute yarn.

Fig. 9 shows the cable being coiled down into the ship's hold at Birkenhead. To facilitate transportation to the docks, it was made in three lengths—maximum 2,750 yds—jointed together as the cable was coiled into the hold (see Fig. 10). A special joint developed by the British Post Office for submarine cable work was used for this purpose.



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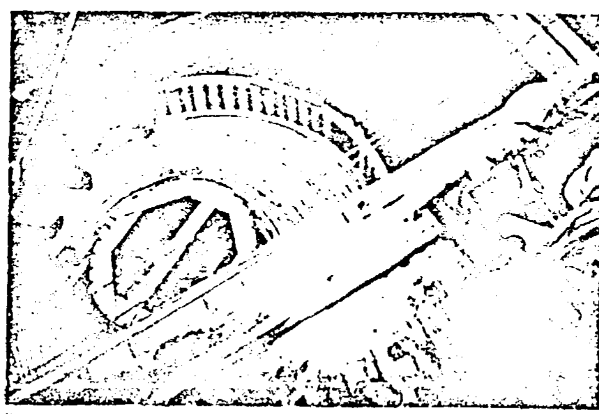

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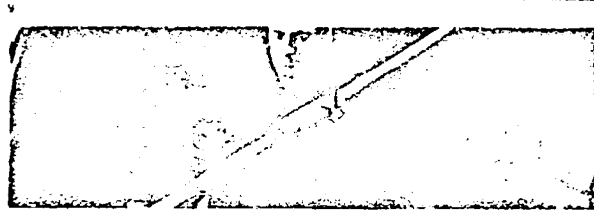

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Dispersion-strengthened lead

The excellent corrosion resistance of lead, recognized for many centuries, has been used to advantage in a wide variety of applications. Furthermore, the metal's softness and malleability allow it to be worked into a multiplicity of shapes with little effort. For certain applications, however, it would be an advantage if the general mechanical properties of lead, and especially its creep and fatigue properties, could be enhanced without reducing its valuable corrosion resistance. A new technique, known as Dispersion Strengthening, promises to bring this about. The strength of a metal may be related to the ease with which the atoms in its crystals will move, relative to one another, under the influence of an externally applied stress. If this movement can be hindered or restricted, the metal will not deform so easily and will become both harder and stronger.

One of the traditional ways of strengthening a metal is by alloying. Here, foreign atoms are introduced into the crystal lattice, and these by reasons of physical size, energy considerations and other factors, provide obstacles to the movement of the parent atoms and, consequently, the crystal distorts less under a given stress. Virtually no pure metal is used in any engineering application today: alloying is nearly always used to produce better mechanical properties.

Alloying, however, is not entirely without its drawbacks and, to circumvent some of these, the technique of dispersion strengthening has been explored. Here, fine particles of foreign materials are incorporated into the parent metal, by one of a variety of methods, to give an improvement in properties equal or superior to that provided by conventional alloying.

A paper by Roberts, Ratcliff and Hughes[1] mentions the improvements attained with dispersion strengthened aluminium, nickel, copper and other metals and reviews the application of the technique to lead. The various methods by which small particles of foreign bodies can be incorporated are discussed and the introduction of lead oxide, PbO, by a powder metal technique is considered to be the simplest approach.

Lenel[2] used another metal—copper—as the dispersed phase. He took advantage of the fact that copper is appreciably soluble in lead at elevated temperatures but virtually insoluble at its freezing point. Melts of lead, containing copper, were prepared in the general range 850-1,000 C and then a fine stream of the molten alloy was 'atomised' by a jet of air. More than half the particles of the resulting fine powder were less than 325 mesh (i.e. 44 microns) and within each frozen droplet were tiny particles of the second element which had precipitated on freezing. The small size of each lead droplet ensured that the particles of the precipitated phase would be in the second order of fineness. On being compacted by mechanical pressure into a solid block of metal, the particles of copper were uniformly dispersed throughout the matrix. In this case the presence of oxygen introduces a complication. The fine lead particles, before compaction, are found to be covered with a film of oxide and, unless this is removed, particles of lead oxide become incorporated in the final product and affect its final strength and ductility. In the case of the copper-lead powder, the oxide can be almost eliminated by heating to about 300 C in a stream of hydrogen for some hours.

For his tests Lenel extruded the powders into wire form by a hydraulic press, at about 40 : 1 ratio, using pressure in the order of 30,000 lbs in. The products were near to the theoretical density. The mechanical properties of the wires are given in the table below, the average particle diameter (and the spacing between each) being calculated on the assumption that all the copper particles were spherical and of uniform size.

Table 1 Tensile properties, oxygen content, interparticle spacing and average copper particle diameter of lead-copper powder extrusions

Copper content wt. %	Tensile strength lb. in.²	Elongation % on 1 in.	Oxygen %	Average spacing between particles	*Average particle diameter*
(a) *as received*					
coarse					
0·5	3800	31	0·49	1·50	0·35
fine					
0·5	5800	7	0·49	1·41	0·33
2·1	5100	29	0·48	1·36	0·50
5·0	6900	20	0·84	1·24	0·61
8·1	7200	3	0·43	1·17	0·66
(b) *reduced*					
coarse					
0·5	3100	47	0·07	1·48	0·35
fine					
0·5	3700	42	0·09	1·43	0·33
2·1	4300	37	0·05	1·39	0·51
5·0	5000	46	0·03	1·25	0·61
8·1	6300	38	0·07	1·16	0·66

If the ultimate tensile strength of pure lead is taken to be about 2,000 p.s.i., then it can be seen that the introduction of the dispersed phase has made an appreciable difference to this property. A study of columns 2, 3 and 4 in both halves of the table shows that the presence of a small amount of oxide both strengthens and embrittles the product.

Table 2 shows the effect on the creep of lead (at 25 C) of adding 0·55% of aluminium. By comparison, it should be remembered that the creep of nearly pure lead is about 1% per year at only 420 lbs. sq. in. at 30 C.

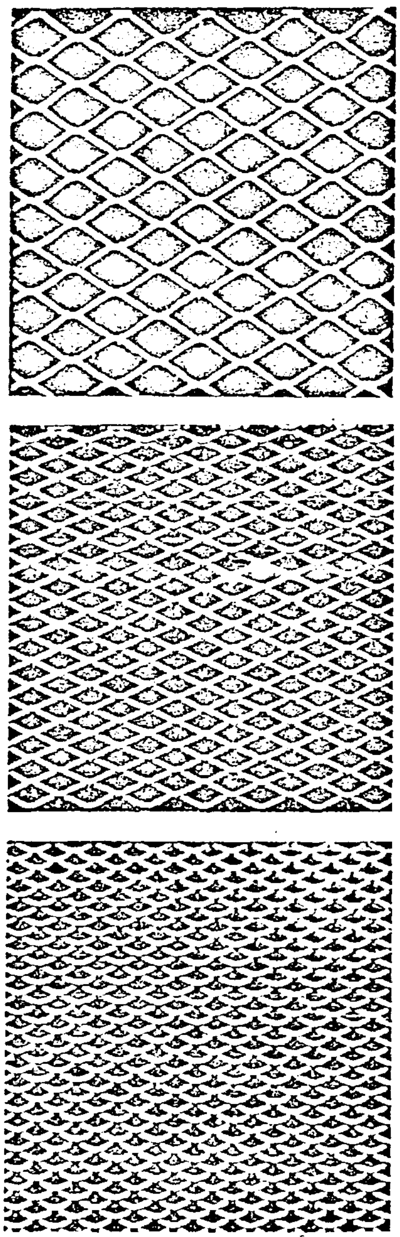
Table 2

Stress lb in.²	*Creep rate % year*	*Duration of test hours*
2000	0·13	1300
2200	0·24	1176
2500	0·60	1000
3000	1·15	Specimen failed after 700 hours

Later work has shown that systems containing discrete particles of metals which have relatively high solubilities in lead at liquid temperatures (e.g. Sb, Ag, Zn or Ca) are not markedly superior to ordinary lead. In particular they are thermally sensitive, and these systems do not appear to merit further study for the time being.

Dispersion of lead oxide alone can also produce strengthening and the lead lead oxide system seems to have advantages over other systems and to offer better promise of industrial exploitation. The amount of oxide may be controlled by varying the particle size of the lead powder—which will usually carry a thin film of oxide on its surface—and also by further treatment of lead powder, in a ball mill for example. Extrusion or rolling techniques can then be used as before to obtain the dispersion strengthened product. At one time it was thought that there was a roughly linear relationship between strength and oxide content, but later work suggests that the nature of the dispersed phase and its degree of dispersion are more important than the actual amount present.

Extrusion temperature itself has an effect, and it is clear that the higher the extrusion temperature, the lower the strength of the product. The dispersion strengthened materials show a pronounced improvement in creep properties, when compared with ordinary lead and Table 3 shows some figures for dispersion strengthened lead, Below – Expanded DS Lead Strip (DS7)



formed from lead powder having an average particle size of 2·5 microns and an oxide (PbO) content of 4·30%.

Table 3 Creep rate

Temp. °C	Stress p.s.i.	Steady-state creep rate %/year	Total duration of test (hrs)	Total elongation in test %
45	1020	0·06	1640	0·09 not fractured
	2000	0·12	2450	0·15 not fractured
	3000	0·34	2100	0·21 not fractured
95	600	1·06	2150	0·58 not fractured
	1000	22·1	1220	3·8 broke
	1900	3900·0	2·65	1·05 broke

By comparison, the creep rate for ordinary lead at 45 C under a stress of 1,000 p.s.i. is in the order of 2,000% per year and fracture would occur in a few hours.

Application of D.S. Lead

Several workers have listed the possible fields of exploitation of dispersion strengthened lead. Evans, Huffman and Warner[3] have made prototype battery grids from expanded dispersion strengthened lead strip, and pointed out that this material, as well as having the necessary strength, has satisfactory corrosion resistance, slightly improved electrical conductivity (compared with conventional antimony lead alloy used for this purpose) and being free from a second metal cannot give rise to self-discharge through 'antimony poisoning'. These views find support in a paper by N. E. Bagshaw and T. A. Hughes[4] who fabricated grids from dispersion strengthened sheet lead and tested them under service conditions with encouraging results.

Cable sheaths may provide a large outlet for this material, in spite of the introduction of alternative cable sheathing materials, lead and conventional lead alloys still find extensive use and are almost invariably specified for the most severe service conditions. The main advantages of lead are impermeability, high corrosion resistance and ease of handling and jointing, all of which are retained by D.S. lead sheaths. The improved strength of D.S. lead would permit a reduction in sheath thickness, which would once again make lead competitive for those types of cable where substitutes are currently being used.

Lead sheet and pipe have always provided a popular outlet for lead in Great Britain, and the principal reason for their retention in this market in the face of strong competition is the ease with which these materials can be worked and installed, coupled with their permanence in service. It is clear, however, that if an alternative type of lead could be provided which was stronger and more rigid in use, and still as corrosion resistant, then the two types could act in complementary roles to one another, particularly in the building and allied industries.

The above is only a brief description of some of the extensive work now in progress on dispersion strengthened lead. The results obtained to date show excellent promise for commercial application of the material and much of the development work is now being carried out by individual sections of industry with specific end uses in view.

References

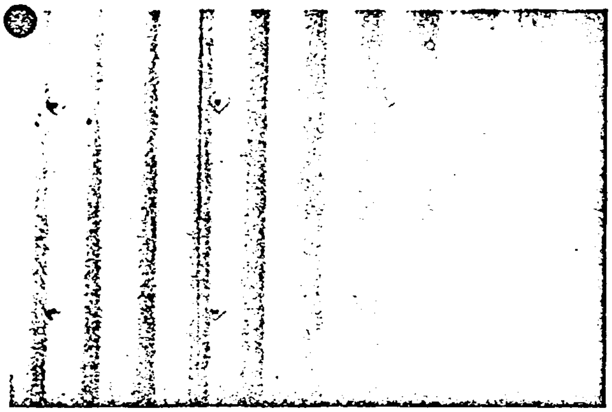
1 D. H. Roberts, N. A. Ratcliff and J. E. Hughes, *Powder Metallurgy* 1962, No. 10, p. 132

2 F. V. Lenel, *Powder Metallurgy* 1962, No. 10, p. 114.

3. D. J. I. Evans, H. R. Huffman and J. P. Warner, *Materials in Design Engineering* 1964, April, p. 105.

4 N. E. Bagshaw and T. A. Hughes, Fourth International Symposium on Batteries, Brighton, September 1964, Paper No. 14.

Calcium plumbate paints for galvanized steel



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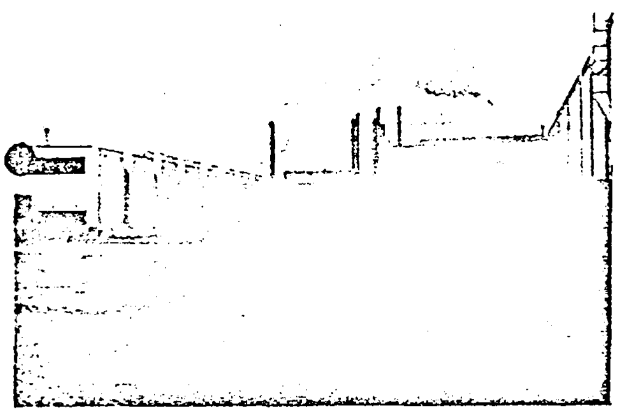
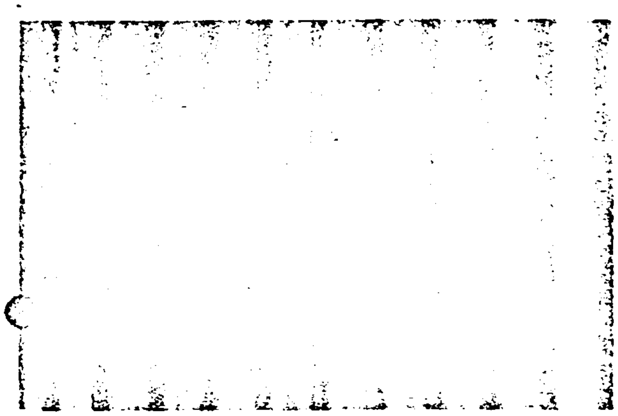




When painting new galvanized steel, it is usually necessary to pre-treat the surface; but it is possible to make a direct application of certain paints incorporating calcium plumbate. This rust inhibiting lead pigment has an almost unique *property that enables paints based on it to adhere well to* galvanized steel without previous treatment, other than simple degreasing.

Some years of practical experience in the use of calcium plumbate primers in this way have proved that they will continue to adhere firmly even after a long period of weathering. The following four summaries of recently compiled case histories demonstrate that confidence in the efficacy of calcium plumbate paint is well founded.

Case 1 The external galvanized sheeting of the steel mill building of the Guest Keen Iron and Steelworks at Cardiff was painted in 1956, using calcium plumbate paint as a primer. The surface was not pre-treated in any way other than degreasing with white spirit, and after priming it was painted with one lead-based undercoat and one lead-based finishing coat. The paint system is subject to quite severe conditions of exposure. There are industrial fumes, deposits of powdered lime and iron oxide, and furthermore the site is within a quarter of a mile from the sea.

An examination in 1962, some six years after the original painting, confirmed that no flaking from the galvanized steel had occurred and at no time had it been necessary to renew the priming. Fig. 1 shows a close-up view of the surface at this time.

Case 2 A new building, erected in the Spring of 1960 at the Abbey Works of the Steel Company of Wales, has galvanized steel cladding painted with two coats of calcium plumbate primer and one coat of an exterior quality bitumen based paint. The surface was prepared simply by degreasing with white spirit.

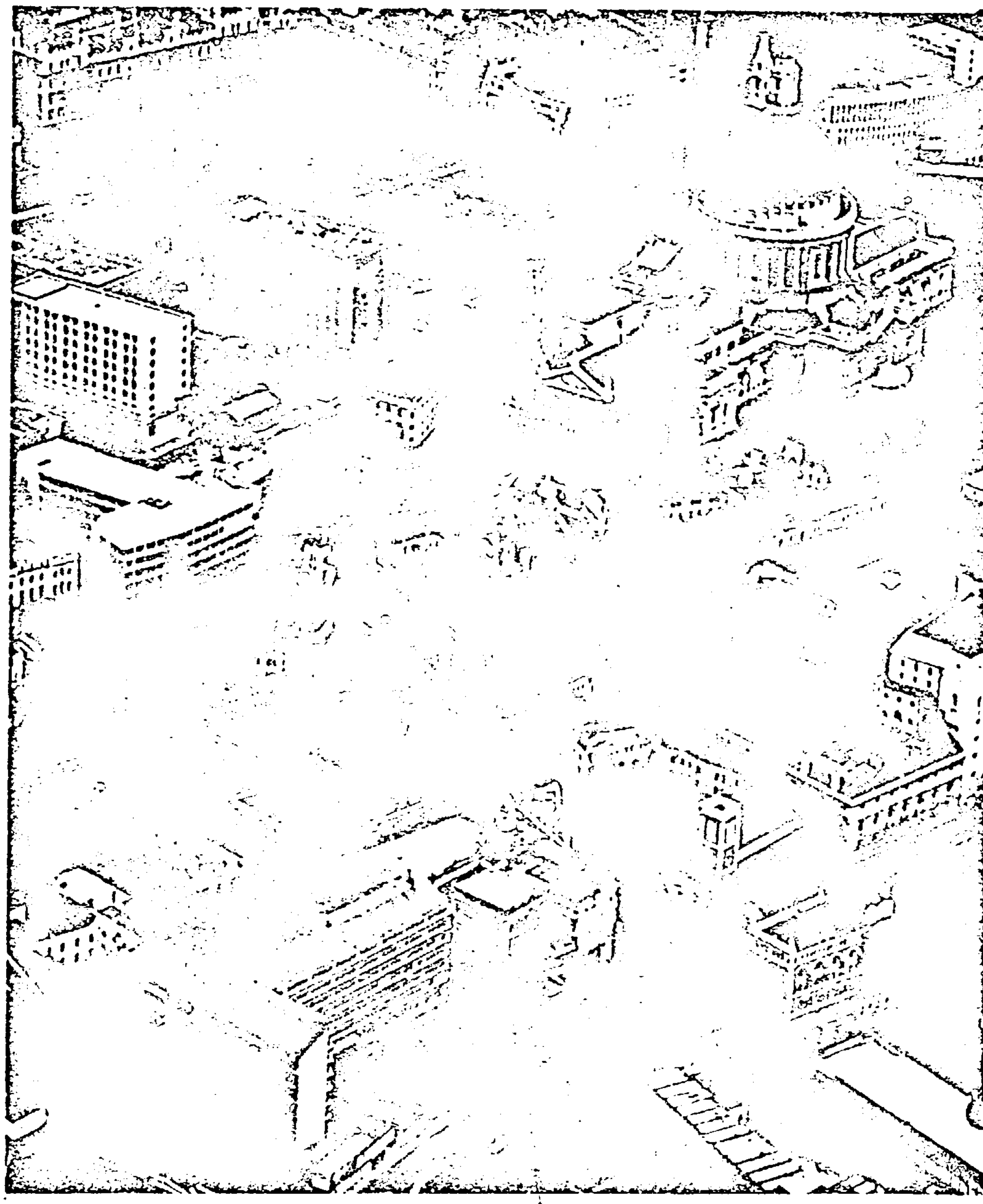
*The site is only a short distance from the coast and there*fore the exposure conditions are partially marine as well as industrial. Fig 2 gives a view of the plant.

An examination of the condition of the paintwork in the summer of 1964, showed that after four years exposure it was still in excellent condition, with no signs of any need for re-priming. Fig. 3 gives a close-up view of the surface at this time.

Case 3 The roof of a power house at Richard, Thomas and Baldwin's works at Scunthorpe was constructed of galvanizing sheeting in 1958 and painted with a calcium plumbate primer and a top coat of white lead phenolic finishing paint, after degreasing with white spirit. The environment is a severe industrial one—a sulphurous atmosphere with depositions of finely powdered lime, coke and iron oxide dust. *Examined late in 1961*, after over three years service, the paintwork was found to be in very good condition with excellent adhesion to the galvanized surface.

Case 4 In 1961 the City of Montreal in Canada began to replace its existing lamp standards with a new design. These standards were fabricated from sheet steel, then hot dip galvanized and painted immediately with a calcium plumbate primer applied by spraying at the galvanizer's works. They were then transported to sites and further painted with an undercoat and finishing coat after erection.

In addition to the general town atmosphere to which the paintwork is exposed, the bases of the standards are subject to attack by salt used for snow clearance during the winter. The specification of galvanizing plus calcium plumbate priming was chosen to avoid the rapid deterioration of the base of the standards that was *previously* experienced. In 1963, after over two years service, the paintwork as a whole was reported to be in good condition, with no failure of adhesion to the galvanized surface.



Lead in modern architecture

[illegible] aerial view of part of the City of London shown in [illegible] 1 serves to illustrate the important role played by [illegible] sheet in building, today as in the past. The dome of St. Paul's, now about 250 years old with most of the original lead covering still intact, will be readily recognized.

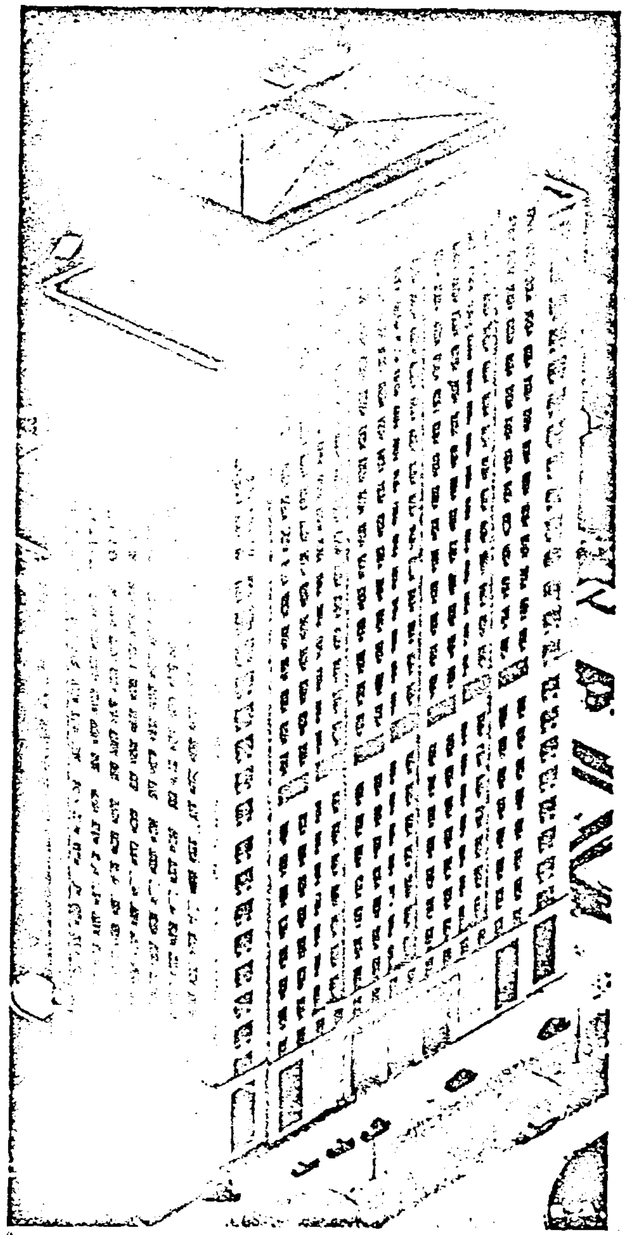
In the lower part of the picture can be seen the impressive new headquarters of 'The Times' newspaper at Printing House Square, the site that has been the home of the paper since its foundation in 1785. When the photograph was taken, all the rebuilding work had not reached the final stage, but the main new buildings are seen complete with their lead-covered pitched roofs. Here, in contrast to the strongly moulded architecture of the St. Paul's dome, the roof has the more simple and sharper lines of contemporary design, to which the use of lead covering is clearly adaptable. Whilst lead sheet is not so widely used for roof coverings today as in the past, it still has no peer as an outstanding roof for outstanding buildings. It will give a very long life with little or no maintenance, even in very exposed positions, and with buildings built to last the best is likely to be the cheapest in the long run.

A view from the air, Fig. 2—is the only way to see, at a glance, the whole of another important modern lead roof, that of the tower block of the Shell Centre, a group of large office buildings standing on Thames side South Bank in London between Waterloo and Westminster Bridges. With a height of 351 ft. this building falls only a little short of that of St. Paul's and the roof is certainly in a very exposed position. With a plan area of 116 by 60 ft. the roof [illegible] with two pitches of about 9 and 23, and with a [illegible] that are 54 x 25 ft. which is penetrated by flues from [illegible]. The [illegible] of large volumes of flue [illegible] containing sulphurous compounds was a special [illegible] influencing the choice of lead since it has a high resistance to corrosion by these aggressive fumes. At a distance the roof is a [illegible] architectural feature of this [illegible] building, and the lead covering blends well with the Portland Stone facing.

[illegible] river, and within sight of another of London's best known historic landmarks—the Tower, is another striking new building that exemplifies the contemporary use of lead sheet. This building at St. Katharine Dock—see Fig. [illegible]—provides a new headquarters and divisional offices for the police force of the Port of London Authority. It is surrounded by excellent examples of 19th century industrial architecture, and has been designed to conform both in [illegible] and silhouette with the warehouses on either side. The [illegible] of architects Andrew Renton & Associates has [illegible] to produce a building of strength and dignity with a [illegible] use of hardwearing and sturdy materials in the tradition of the existing dock buildings.

One important use of lead sheet on this building is as external cladding for the residential apartment that is superimposed on the main flat roof. Fig. 5 gives a general view of the apartment and shows the scope of the leadwork [illegible] the covering for fascias and the tank house. As can be seen from the close up, Fig. 6, the leadwork has clean, [illegible] lines, to which the vertical welted joints add visual interest. Lead sheet, despite its comparatively low mechanical strength, can be applied to near vertical or vertical surfaces fully satisfactorily, by providing fixings at the right spacing to give proper support.

[illegible] important use of lead on the St. Katharine Dock [illegible] is for damp proof courses incorporated into the [illegible] (It is also extensively used in a similar way [illegible] Times and Shell buildings.) The superstructure [illegible] of strongly modelled precast concrete units [illegible] crushed flint exposed aggregate giving a dark rich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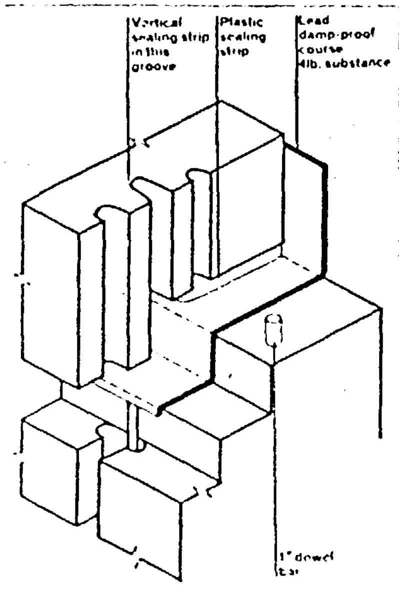

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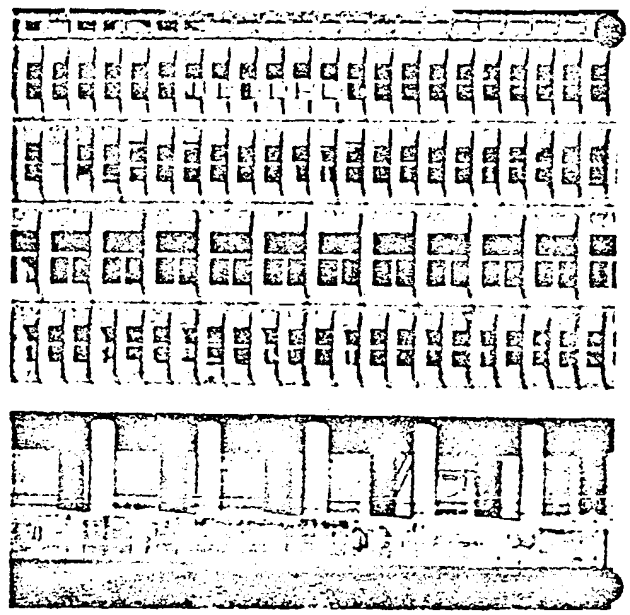
[illegible] to blend with the adjacent brickwork. The pre-[illegible] concrete elements are of storey height and [illegible] a method of construction broadly similar to the [illegible] systems used nowadays for repetition [illegible] for housing. Thus the joints between the elements are constructed dry, the horizontal joints being formed with a step to give a lap and the vertical joints being designed with weather check grooves incorporating a flexible sealing strip. In addition, to ensure a weathertight wall, the hori-[illegible] joints have a strip of lead sheet (4 lb sq ft substance) [illegible] incorporated in them for the purpose of ensuring that any moisture collected in the vertical joints is shed outwards at each floor level, see Fig. 3.

Lead sheet undoubtedly offers several advantages over other materials for such damp proof courses, since it provides a tough and impermeable membrane of high corrosion resistance, which is easily shaped and will bed down well in position to ensure a close fit and even load distribution.



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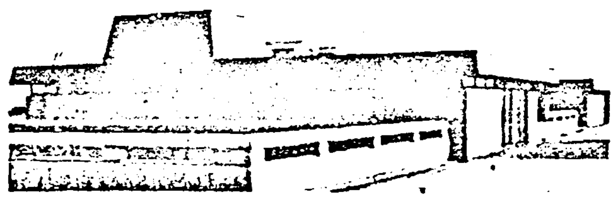

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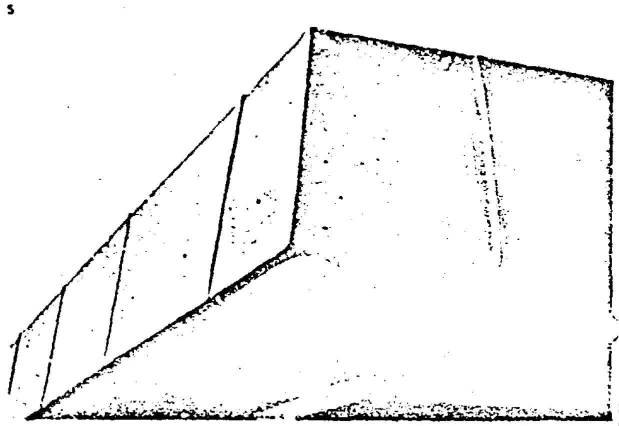

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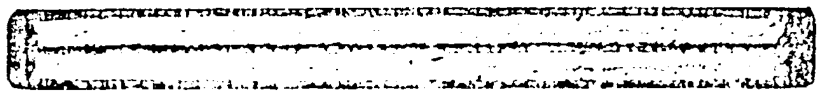
Lead/asbestos anti-vibration pads



For many years pads comprising lead sheet and compacted fibrous material have been successfully used as anti-vibration mountings, both in Europe and the USA. The pads are made in various forms, but they consist basically of layers of lead sheet and layers of asbestos or wood fibre board. Shown above is a cut section of a typical pad developed in the USA. Its thickness is 1¼ in. and the outer layer of lead sheet, about ⅛ in. thick, encloses two layers of asbestos board separated by a steel sheet stiffener.

It seems that such pads were first used in building nearly 50 years ago when, on the recommendation of the New York Central Railroad, they were installed to isolate buildings on Park Avenue from the vibrations caused by the passage of trains on the adjoining railway. Since then the use of the pads has become an accepted method of reducing the transmission of vibrations from rail and road traffic into buildings, and among important buildings recently isolated in this way are the new Union Carbide and Pan-Am buildings, both in New York.

After their introduction for structural isolation in buildings, the pads were subsequently applied in the USA as mountings for heavy machinery, a well-known example being the newspaper presses of the New York Herald Tribune. The European use of the pads has in fact, until quite recently, been confined to the engineering industry. Machines mounted on the pads (usually the lead fibreboard type) are quite common in France and the UK, where they have been widely used under drop hammers and forges and also under machinery that is particularly sensitive to vibration.

The efficacy of lead asbestos pads has thus been demonstrated over the last 50 years in a wide range of practical applications. Only in recent years, however, has there been a systematic attempt to measure the characteristics of the pads under varying loads and over a wide range of frequencies. This work is being carried out by the International Lead Zinc Research Organisation. Special field tests have been carried out in conjunction with the laboratory investigation, and in addition the performance of pads in several well known applications has been closely studied and, where possible, measurements of the degree of isolation achieved have been made.

It has been shown that, as the bearing load is increased from 200 p.s.i. to about 1,000 p.s.i., the performance of the pads is improved and they become effective at lower frequencies. At present the theory of the behaviour of the pads is still not fully understood, but the stage has been reached where operating conditions can be reasonably well defined—particularly in building applications. It is interesting to note that isolation values predicted from theoretical considerations have invariably proved to be lower than those actually achieved in practice. Results for two particular building installations are described below.

The Philharmonic Hall in the new Lincoln Centre for the Performing Arts in New York is built over a subway railroad, and lead asbestos pads were installed under the building columns to isolate it from the vibrations caused by the traffic. Stacks of pads making a total thickness of 3 in. were placed under the columns nearest to the railway but the thickness was reduced for columns further away. From a wide range of measurements carried out on site the consultants concerned have assigned a value of 10-15 dB for the low frequency vibration reduction. Since low frequency vibration is in fact most likely to cause annoyance, this is a very satisfactory result and a marked improvement on the estimate of pad performance that would have been made from the early research results.

The second application concerns the Queen Elizabeth Hotel in Montreal. The hotel building is immediately adjacent to the Dorchester Boulevard Bridge, both structures being located directly above a large array of tracks of the Central Station of Canadian National Railways. Since the columns of the hotel are isolated and those of the bridge are not, the situation is very suitable for a direct comparison between an isolated and unisolated structure.

Measurements were taken simultaneously at the same levels in columns side by side, when trains were travelling on the tracks at distances from the columns of 17 to 220 ft. Based on these measurements the consultants calculated that an average reduction of 8 dB had been achieved over the low frequency range (20-300 c.p.s.) of vibration—again a better result than was expected. More accurate prediction of pad behaviours should ultimately be possible.

In Europe, developments have taken place along somewhat different lines, because the use of the pads has until recently been confined to machinery mountings. The lead wood fibre board pad has been the type used for this purpose, either to isolate the machine from general vibration, or to prevent vibration from the machine being transmitted through the shop floor to other equipment.

Measurements made in 1935 at the Geneva School of Horology indicated that the pads behaved as 'elastic' materials under loads between 15 p.s.i. and 215 p.s.i. Based on this finding, nearly all pad installations have been designed to ensure that the total of static plus dynamic loading does not exceed 200 p.s.i. To isolate forges, this often means that the pad area is calculated on a static loading of less than 20 p.s.i., giving a capacity of up to 180 p.s.i. for the dynamic loading without exceeding the 'elastic limit'.

Obviously, such a high dynamic loading is possible with a forge, but there are many machine applications where the dynamic loading is unlikely to be so much in excess of the static load. In spite of this, the limiting of static loading to such low figures has become virtually standard practice in the UK for machine mountings.

In 1962 a series of tests was carried out by the Lille Institute of Fluid Mechanics on the effectiveness of pad isolation under the concrete foundation block of a grinding machine. In these tests, pads 1 in. thick were installed over a sufficiently large area to reduce the static loading to 14·2 p.s.i. Measurements of vibration amplitude were taken in three directions, at right angles on the concrete block, and in the same directions nearby on the shop floor. Transmission factors of 0·065, 0·17 and 0·14 were obtained which can be expressed approximately as isolations of 24, 15 and 17 dB. Other measurements carried out under varying conditions emphasized the vital importance of ensuring that there is no possibility of bridging or short circuiting which can minimize the value of the pads. Tests on other machine tools planned in the UK will, it is hoped, yield further reliable design data.

Taken together the American and European test results indicate that effective isolation can be achieved at 'high' or 'low' loads; the relatively poor performance obtained at intermediate loads being associated with the natural frequency of the pads. Low loads are not practicable, however, as far as building applications are concerned, and in the Montreal application described, for example, specially designed column bases were required to keep the loading down to the 900 p.s.i. range.

For building applications of the pads in the UK, the American practice of using the high loadings is being followed. Examples are, the rebuilding work at Sloane Square Station, London, and at New Street Station in Birmingham, which are perhaps the forerunners of a more extensive future use of the pads for this purpose in the UK.