Dustroyd, a patent liquid preparation manufactured from tar, has pleasing odor, is not soluble in water and binds road surface. It cost in England £4 per ton, but, having to be used full strength, does not go so far as westrumite, and would probably be as costly.

Akonia is another patent preparation, and so far seems to occupy a similar position to Dustroyd.

In 1902-3 and -4, Mr. John A. Brodie, M. Inst., C.E., City Engineer of Liverpool, conducted extensive experiments with oil mixtures, and the following brief summary of the results will be of interest:—Experiments were made with creosote oil, hot and cold, also mixed with pitch, resin, and tallow; coal tar hot; cheap waste petroleum; westrumite; crystallised creosote; pyneoline; and calcium chloride.

The cost varied from $\frac{1}{4}$d. to $\frac{1}{2}$d. per square yard per coat, the lowest being that of cheap crude oil. Chief objections were raised to the smell of creosote oil, but it banished flies. The surface having the cleanest and whitest appearance was that coated with creosote oil mixed with resin, while that covered with the same oil mixed with tallow had the least odor. The crude Texas petroleum gave the most lasting results, and portions of the road which were heavily coated showed a somewhat glazed surface formed of oil and dust. The experiments showed that the dust had been satisfactory laid, and the experience gained would probably enable future trials to be carried out more economically. From the point of view of wear and tear of the road surface, the oiling was on the whole advantageous; the wear appeared to be less; the surface of the road dried more quickly after rain; the number of loose stones picked up was reduced; the combination of earth and dust on the surface also appeared to make it a somewhat quieter surface. Westrumite was found too costly, and its effects passed off under a fortnight. In the moist climate of England it was found that calcium chloride, costing ⅛d. per square yard per application, promised to give good results. In France calcium chloride was used over 50 years ago, and gave good results where the streets were periodically watered.

In Adelaide the City Council under my direction made several experiments with phenolic, which is a preparation of crude petroleum and is miscible in water to a considerable degree. The oil is not saponified, as is the case with other soluble oil preparations, but when mixed in the proportion of one of oil and two to four of water becomes thicker. It is spread on the roads from a centrifugal watervan with perfect ease, and covers splendidly with one gallon of mixture to three to five square yards of surface, costing ¼d. per square yard. One application lasts a month under ordinary circumstances, and three weeks under heavy traffic. Apart from its dust-laying qualities, it can be applied at any season of the year, and the surface treated does not produce mud in winter, and the life of the road is materially extended. It was found sufficient for light trafficked roads to give six applications per annum, monthly during January, February, March, April, November and December; and 10 three-weekly applications on heavy trafficked roads. The behaviour of phenolic on the Adelaide roads seemed to bear out Mr. Brodie's conclusions from the results of his experiments in Liverpool. Another good feature is that its use in streets that are watered greatly reduces the tendency of the surface to form ruts and become corduroyed or wavy.

To-day these patent preparations have practically passed out of use for reasons given, and because of the necessity for frequent applications. Seawater is still used in places, but like calcium chloride, it affects metal and fabrics, and is not to be generally recommended.

Tar-dressing or tar-spray is, however, still largely adopted in places, and I would like to mention one point only in connection with its use. Having experimented with it for some years, I have found the following method gives best results when applied to new macadam surfaces, or old ones in good condition.

Tar-Spraying or Tar-Dressing.

This method should only be attempted during dry weather in the summer season. First lightly water and sweep the surface at say 7 a.m., then again water surface lightly, so as not to flow off; by 9 a.m. the surface will appear dry, but beneath is still damp. Now apply crude gas tar, and broom it well into surface of road. The damp surface holds metal firmly and tar will not "ball up" with dust under action of brooms, as would be the case if the road had not been watered, and the water and ammoniacal liquor and light oils in the tar readily take up with the moisture in the macadam and carry the tar down from ½in. to 1in. While tar is still fluid, but drying, spread sand lightly over surface (one cubic yard to 40 gallons tar) to mop surplus tar and prevent nuisance to traffic. In about a week or more, according to traffic, the surface skin of tar and sand have become compressed or worn thin showing the metal clearly defined. Now brush surface clean and apply hot distilled tar, and sand surface just as tar shows signs of drying in patches. Distilled tar will not penetrate good macadam suffciently if applied to a dry macadam surface, which is always dusty. Also it "balls up" with the dust, chills and leaves a skin of tar and sand not adhering to surface which ultimately flakes off or becomes mud in wet weather. The first tarring overcomes this trouble and becomes quite hot in the sun, does not chill the distilled tar, and makes a perfect bond with the latter. Once a year, or less frequently, the surface is maintained by fresh application of hot distilled tar and sand. In this way, the life of macadam is much extended, it is practically impervious, and almost dustless.

There are several kinds of tar macadam pavement in use. Ordinary macadam may be mixed with tar to form tar concrete, or the metal may be spread in one or more coats well rolled-in dry and then receive a matrix of hot distilled tar and sand, with sand lightly spread over surface as in the case of tar-paving. Gladwell's system, which was formerly recognised by the Council of the Roads Improvement Association in England, consisted in spreading over the surface a $\frac{3}{4}$ inch layer of tarred chippings, upon which is spread the broken road metal, which metal is then rolled into the tarred chippings, causing the chippings to rise into the interstices between the metal. On the surface of the macadam is then spread a coating of similar tarred chippings, which is rolled into the surface to further consolidate and fill the interstices, after which the surface is sealed by washing with a hot tar preparation. and lastly dry chippings are spread over it. The tar preparation used throughout is that patented under the name of "Tarvia," which is a good improved distilled tar, to which fact any virtues this class of pavement may have, must be attributed. The method had been used before Mr. Gladwell was born, but the "Tarvia" was his. The resulting pavement is not so dense as other similar pavements and is not considered so good.

Tarmac, another patented improvement of distilled tar, is distilled tar to which have been added pitch, resin, and cement. It is undoubtedly a very good article, perhaps the best patented line, but with properly distilled tar, blended with pitch and creosote oil if necessary, the best results can be obtained and there is no necessity to pay the greatly increased price for the proprietary article.

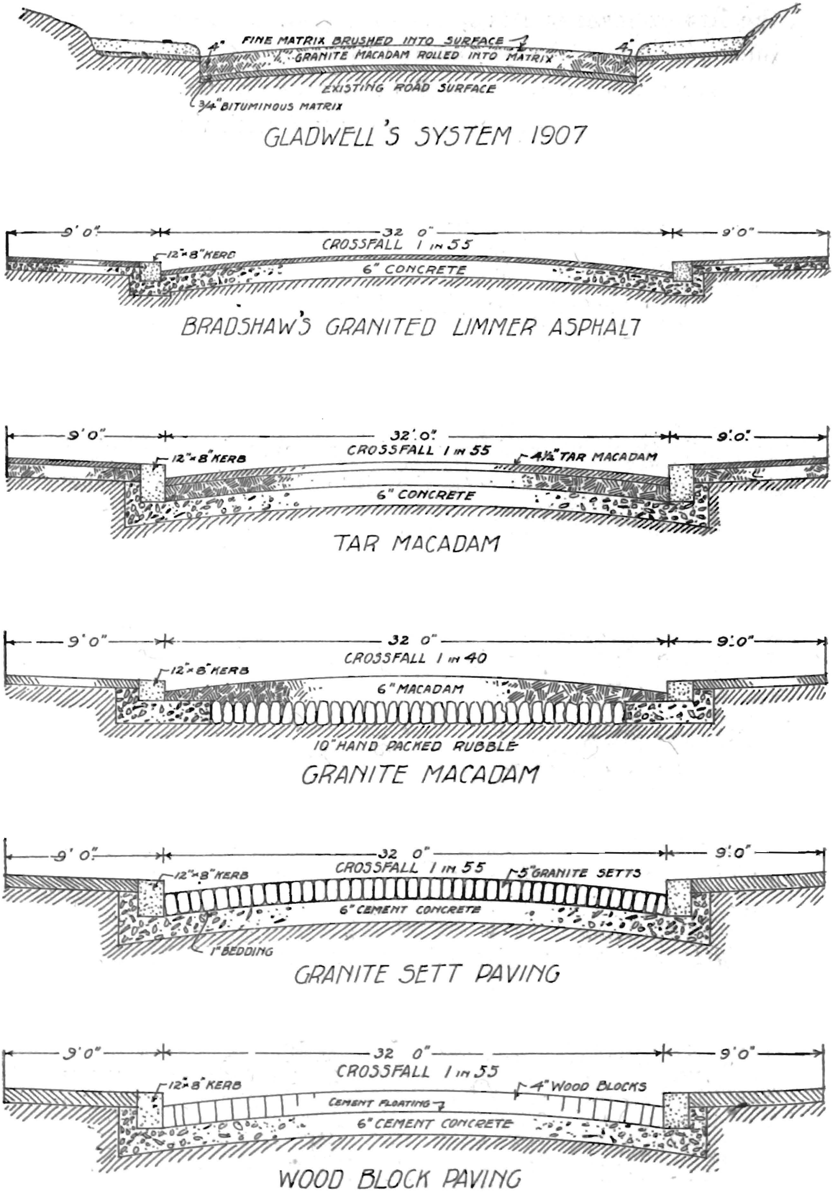
FINE MATRIX BRUSHED INTO SURFACE
GRANITE MACADAM ROLLED INTO MATRIX
4"
4"
EXISTING ROAD SURFACE
3/4" BITUMINOUS MATRIX
GLADWELL'S SYSTEM 1907
9' 0"
32' 0"
9' 0"
CROSSFALL 1 IN 55
12" × 8" KERB
6" CONCRETE
BRADSHAW'S GRANITED LIMMER ASPHALT
9' 0"
32' 0"
9' 0"
CROSSFALL 1 IN 55
12" × 8" KERB
4½" TAR MACADAM
6" CONCRETE
TAR MACADAM
9' 0"
32' 0"
9' 0"
CROSSFALL 1 IN 40
12" × 8" KERB
6" MACADAM
10" HAND PACKED RUBBLE
GRANITE MACADAM
9' 0"
32' 0"
9' 0"
CROSSFALL 1 IN 55
12" × 8" KERB
5" GRANITE SETTS
6" CEMENT CONCRETE
1" BEDDING
GRANITE SETT PAVING
9' 0"
32' 0"
9' 0"
CROSSFALL 1 IN 55
12" × 8" KERB
4" WOOD BLOCKS
CEMENT FLOATING
6" CEMENT CONCRETE
WOOD BLOCK PAVING

Fig. 3.

The tar grouting method consists of spreading and rolling dry macadam, then pouring over the surface hot refined tar, about one gallon per square yard, and rolling again after which ½ inch (consolidated) in thickness of tarred chippings are spread and well rolled into surface with a light road roller.

Finally, the surface is dusted with fine stuff from hard metal to take up surface tar. The top coating (½ inch) may be reduced to a mere blinding coat, which affords better foothold for horses, but does not so effectually seal the surface from rain. The drawback to this system is that it is impossible to ensure the uniform filling of voids. It has given good results, as well as bad, sometimes through unfavourable weather, sometimes through other causes.

Pitch macadam is similar to the above, except that sand is added to the tar in grouting. As laid in Liverpool it consists of a lower course, 3½ inches thick of 2 inch gauge metal, rolled dry with a heavy roller, grouted with a mixture of hot pitch and sand, or refined tar and sand, and again rolled to consolidate the mass and reduce the interstices. A second layer of metal 1½ inch gauge, 2 inches thick is immediately laid on the first coat and in a similar manner, except that a little cement is added and the surface is blinded with dry chippings. The surface is then rolled with a light roller.

The pitch or distilled tar for this pavement should be distilled up to 270° C., and should have a specific gravity of 1.278 at 15.5°C. The matrix consists of 9 gallons pitch or tar to one cwt. sand for lower course, and for the upper course 2lbs. of cement are added for each cwt. of sand.

This pavement is, perhaps, the best of its kind which has been produced, and the samples of it which I saw in Liverpool looked extremely fine and required a minimum of maintenance.

All these tar macadam roads are laid on proper foundations. Good drainage and sufficient foundations are the great desiderata of modern pavements. Only by this means can heavy concentrated wheel loads of to-day be adequately distributed over the formation and prevent the crippling of the wearing coat by buckling.

Ordinary macadam may have a hand-packed stone foundation of the Telford type for heaviest traffic, or be composed of good quality strong 4 to 6 inch gauge stone, on a properly-prepared and rolled formation. This foundation course may be from 8 inches to 12 inches thick (generally hand-broken in site), blinded with spallings. On this one or two coats of metal may be laid. If one it would be about 6 inches loose or $4\frac{1}{2}$ inches when consolidated. If two, the united thickness would be 5 inches consolidated. Where good quality marl blinding is available it may be spread dry on the surface of each coat before rolling, then rolled dry, and again while being watered. This produces a first-class macadam, and only 12 per cent. to 18 per cent. of blinding is required. This quantity is not detrimental, produces little mud in wet weather, and does not prevent proper consolidation of metal.

Twenty-four hours after road has been finished, the water in blinding will have evaporated near the surface, causing blinding to shrink and leave metal somewhat loose. Therefore, a thin coating of screenings $\frac{3}{4}$ inch gauge to dust should be spread and rolled in to firmly wedge metal and produce a surface almost free from clay or earth, and almost wholly grit.

MACADAM.—Table giving results of analyses of Macadam roads in Adelaide, compared with results obtained by Codrington in Wales.

	Under $\frac{7}{8}$	Over $\frac{5}{8}$ Under $\frac{7}{8}$	Over $\frac{3}{8}$ Under $\frac{5}{8}$	Over $\frac{1}{4}$ Under $\frac{3}{8}$	Over $\frac{1}{12}$ Under $\frac{1}{4}$	Under $\frac{1}{12}$
	%	%	%	% Over $\frac{1}{30}$ Under $\frac{3}{8}$	%	% Under $\frac{1}{30}$
CODRINGTON—						
Basalt stone in good condition	46·8	14·3	6·3	10·7		21·9
					32·6	
Limestone, good	45	12·7	63	14·5		21·5
					36	
,, poor	21·5	16·0	10·5	28·0		24
					52	
ADELAIDE—						
Quartzite: Gauge						
1 year old $2\frac{1}{2}-1''$	40	15	9·5	4·5	14	17
					35·5	
2 ,, $2\frac{1}{2}-1''$	43·0	12·3	8·7	5	12·6	13·4
					31	
3 ,, $2\frac{1}{2}-1''$	43	17	10	6	12·7	11·3
					30	

I have found that the best macadam road when fairly worn contains up to 40 per cent. of fine grit and dust which will pass through a $\frac{1}{2}$ inch screen. No matter how the blinding was added, or whether it was sand, chippings, or marl, the same result was obtained and the life of the macadam was the same, but the cost was least when marl was used as described.

There is another kind of macadam pavement which is easily the best, but, unfortunately, not now available. It is simply rock asphalte as mined, broken to a 3 or 4 inch gauge as a maximum, and spread on the usual foundation course or on top of existing worn macadam, and rolled to a thickness of 2 to 3 inches. I have seen these pavements in Worthing, England, and they were better than anything I had seen anywhere except wood blocks or the more expensive type of rock asphalte paving as laid in Sydney and elsewhere. It cost 7/6 f.o.b., and under all but very heavy traffic had a life of at least twice to three times that of ordinary macadam.

In the case of the Norfolk Suspension Bridge, England, the macadam road pavement was over 2ft. thick, and, owing to increasing and heavier traffic, it was decided to reduce the load. Consequently, the thickness of pavement was reduced to 12 inches and a wearing surface of rock asphalte macadam 3 inches thick was added. The result was admirable, and after several years' use, I could not detect any signs of wear. The same remarks apply to the streets in Worthing, England, which were similarly surfaced.

I do not intend to say much about stone sett or rock asphalte paving. When the best stone is available, setts make the most durable surface, they are, however, too noisy and rough for main city streets and too costly for secondary streets and main roads; but in the vicinity of wharves stand up to heaviest traffic admirably.

Powdered rock asphalte undoubtedly makes the best city street pavement, but should not be used on steep gradients, probably 1 in 25 is a limit.

There is another type of mineral asphalte which gives splendid results as a pavement. It consists of 1½ inch compressed asphalte plates in squares 9 inches wide, on a concrete foundation. On top of the concrete, after the surface has been watered a ⅜ inch course of cement and sand 1:3 is spread dry. On this the plates are laid. The edges of plates are painted with asphaltic mastic, which causes the plates to become firmly united. Traffic can be turned on within 24 hours. Patches of a street paved in this way were opened up for my benefit in Cologne, and I found the sand and cement thoroughly set after 24 hours. A sample of this pavement, supplied by the Limmer Co., of London, was laid in Gawler Place, Adelaide, eight years ago, and is still in perfect condition under heavy traffic.

As regards wood blocks, there are a few special points to which I wish to direct attention. First by laying the blocks in courses at right angles to the line of road, expansion and contraction is facilitated; the great longitudinal extent of paving when contracting frees each transverse course, the blocks of which are worked outwards by the traffic, but cannot expand back into place again, as they become gripped by the greater longitudinal expansion. Then the gaps get filled with dirt, etc., and further expansion of the pavement as a whole upsets the kerbs unless sufficient provision is made for expansion, which is difficult. When the blocks are laid diagonally to line of road, there is the same extent of blocking expanding lengthwise of, and at right angles to, the courses. This better maintains blocks in position and reduces effects of expansion and contraction. I do not approve the longitudinal expansion joint as used in Sydney. It is almost impossible to satisfactorily maintain it, also it is difficult to make it of sufficient thickness to be effective. I used animal pitch and granular cork or sand mixed hot in the proportion of 3 or 4 to 1, and run into sheets 1in. thick and cut into strips the same width as the thickness of block, usually 3 inches. These were placed between the ends of blocks 3 or 4 lots to each course on each side of pavement. If they became squeezed out, it was an easy matter to lift one block, cut it, move the others out and insert fresh jointing. In this way the kerbing was never affected. Where the width of street permits, it is a good plan to pave a margin of 4 to 6 feet from the kerb with brick on edge or stone setts or blocks in cement. This also assists to resist the expansion of wood blocks and save kerbs.

Further the surface of wood block pavement should be kept well coated with distilled tar and sand or fine gravel. This prevents access of moisture to blocks and greatly reduces expansion and contraction.

Brick pavements have been laid down in America to a moderate extent. They are laid on a concrete foundation, and set in cement mortar or dry sand. Sand joints are objected to as unsanitary and productive of undue wear; cement mortar makes the brick pavement noisy, and in many instances the expansion of the bricks has caused them to part from the foundation and buckle up. Where suitable bricks can be had at reasonable price, this pavement is satisfactory, and under moderate traffic has a life of from 10 to 15 years.

CONCRETE ROADS.

As the successful construction of concrete roads was first practically demonstrated in America, and as their experiments have been scientifically carried out, observed, reported upon, and discussed, I cannot do better than quote from the Reports of the two National Conferences for 1914 and 1916, and in conclusion refer to recent Australian practice.

Mr. Goss, of America, thus prefaces his remarks on the subject of concrete roads:—"The good roads of the Old World (Europe) have been built by people who live under settled conditions, or they have been developed in response to the exigencies of war." How much better is it to develop our roads in response to the requirements and necessities of commerce and the development of our country. They should then serve the most useful purpose, and the primary purpose for which they should exist. Then they should surely be constructed in the best manner possible according to our means and from an economic aspect.

"The good road of a decade ago is no longer sufficient to withstand the traffic of the present day. The horse is giving way to the motor; the light vehicle is being superseded by the heavy truck, and the speed with which all traffic moves is increasing."

As now constructed, concrete roads have good life, stand heavy traffic and stand high as an economic pavement.

Briefly, the following selected summary indicates the lines on which experiments have been carried out, with recommendations as to construction:—

Provide for efficient drainage; properly prepare road bed to secure uniform condition; set up side forms and steel plates 3in. x 3-16in. x 25ft., or further apart, at expansion joints, supported on each side by anchor plates 6in. long let into concrete; use cement concrete of clean screened washed gravel or first class broken stone screenings ¼in. to 1½in. gauge, and clean washed sand free from clay mixed in proportion of 1:1½:3, 1:2:3, or 1:2:4, according to circumstances, mixed to form wet mixture in batch mixer, turned for one minute at rate of 10 to 16 revolutions per minute; wet formation before laying concrete; screen off surface of concrete, and finish with wooden floats; when set, 24 hours after laying, cover with sand or other material for two weeks, and regularly sprinkle with water and keep moist; after four weeks in warm weather, or six to eight weeks in cold, open for traffic; a road so constructed has successfully carried a traffic of 2500 vehicles per day; cost of maintenance was £20 per mile for first five years.

Forest Home Drive, near Sibley College (1909):—(a) 530ft. long, (b) 35ft. long; foundation course crushed limestone, wearing course 4in. thick, concrete (a) 1:2:5 of crushed limestone, composed of 5 parts $1\frac{1}{4}$in. to $2\frac{1}{4}$in. gauge to 3 parts $\frac{1}{2}$in. to $1\frac{1}{4}$in. gauge; (b) 1:2:6 of crushed cinders graded similarly to limestone; batch mixed, tamped by hand till mortar flushes to surface, laid in winter, covered with leaves for fifteen days; not sprinkled; traffic turned on after fifteen days; surface treated in summer with asphaltic oils and refined tar, not a success, but surface painted annually; cracked longitudinally at one place at side owing to defective foundation; cinder concrete more excessively, but maintained good surface.

Port Richmond (1910):—Concrete 1 barrel cement to 8 cubic feet sand to 16 cubic feet crushed stone $\frac{3}{4}$ inch to $1\frac{1}{2}$ inch gauge, to 40lbs. to 60lbs. oil; mixed in batch mixer; laid 4in. thick, no expansion joints, sloping construction joints; cracks longitudinal transverse.

Bergen County, N.J. (1910):—Concrete laid on two bridges 25 and 37 feet long, wooden floors; concrete 6in. thick in centre, $4\frac{1}{2}$in. at sides, laid on iron sheathing and **reinforced** with wire netting; mixed 1:2:4 crushed trap $\frac{1}{4}$in. to $\frac{3}{4}$in. gauge, and 15 per cent. oil by weight of cement, hand mixed, shovelled in, and tamped; no sign of wear in 1914.

Hillside Avenue (1911):—Street 173ft. x 24ft., avenue between New York City and Long Island; 1830 vehicles per day; concrete 1:2:4 crushed trap $\frac{1}{4}$in. to $\frac{3}{4}$in. gauge, and 10 per cent. oil by weight of cement; 4in. thick, match mixed, tamped, 1 expansion joint in centre of wood blocks, 2 courses each, 3in. wide and 4in. deep on sand run in with asphalt; remained perfect, and edges of concrete protected and not broken; several small areas