The Mechanical Spraying of Roads

By A. E. Callaway*

During the year ended June 30, 1925, the Victorian country roads board completed a length of 151 miles of surface spraying, 24 miles being sprayed with tar and 127 miles with bitumen, and it is anticipated that during the present year a length of 217 miles of road will be sprayed and a considerable length of penetration work done. To enable this to be effected two additional sprayers have been designed specially for the work, and details of these machines are herewith given.

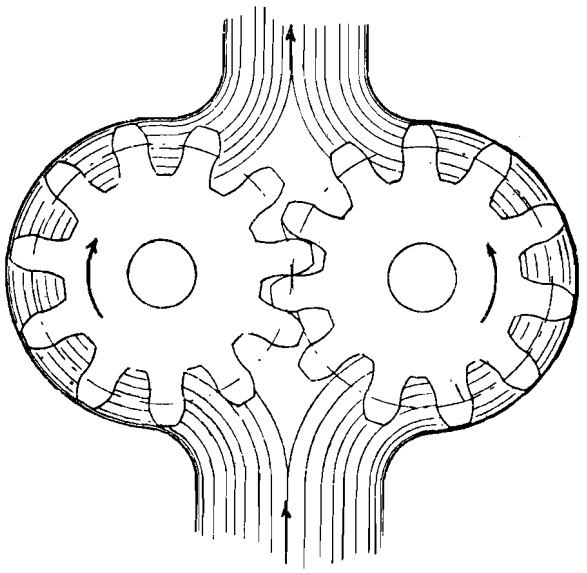

Fig. 1. Diagram of Rotary Pump

The machine for spraying consists of a steam wagon of suitable design, with wheels of ample dimensions, on the chassis of which is mounted a rectangular tank of 800 gal. capacity. From the bottom of this tank a suction pipe leads to a rotary geared pump which is mounted on the rear of the chassis and driven through gearing off the main driving wheel of the wagon. The pump outlet leads to the spraying manifold, which is a horizontal pipe at the rear of the wagon and running its full width, and about 9 in. above the road surface. This is fitted with a number of jets so shaped that the tar or bitumen is sprayed uniformly over the road surface.

The older machines are capable of spraying widths up to 8 ft. at a rate of $\frac{1}{4}$ gal. to 1/5 gal. to the sq. yd., the pump being driven by sprocket wheels and chain from the main axle with clutch on the pump shaft. To suit the newer widths of roads in use (up to 20 ft.) and to allow more flexibility in their treatment, the new machines were designed to spray widths up to 10 ft., and at rates of 0.2 gal. to 1.0 gal. to the sq. yd.

The increase in widths sprayed was obtained by extending the manifold and by slightly enlarging the pump. The varying rates of spray were obtained by the insertion of extra countershafts and gearing between the main driving axle and the pump axle; one pair of gear wheels was so placed that they could be readily ex-

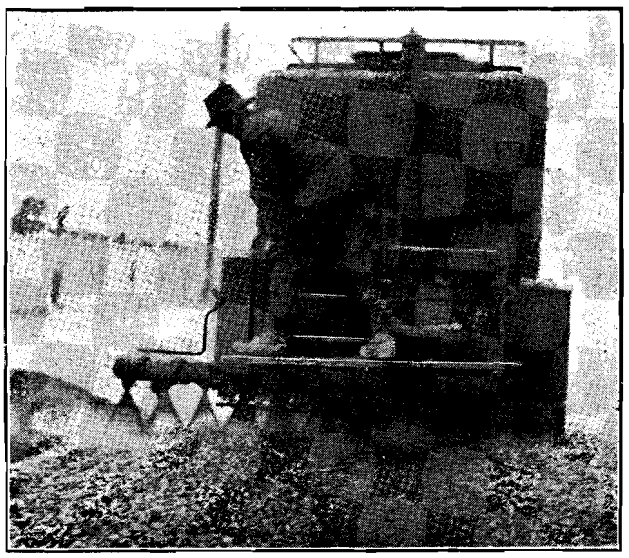

Fig. 2. The Spraying Machine at Work

The pump and delivery pipe are on the right of the operator's foot; the vertical pipe with the valve at the top is for the return of excess bitumen to the tank. The change-gear wheels are located between the countershaft and pump spindle under the hood to the left of the operator.

changed for other wheels having a varying ratio between the number of teeth, viz., the total number of teeth on the two wheels are 80, and the wheels are provided in pairs as, 40-40, 46-34, 54-26, 60-20, and 64-16. This gives a wide range of pump speeds.

Other improvements on the previous machines include an increase in the diameter of the suction, delivery and manifold pipes, and the lagging of these and the pump to reduce heat losses.

The machines have been tested on all classes of work and the following details are given:— Pump gears (Fig. 1): Overall diameter, 6.5 in.; width of face, 8.5 in.; number of teeth, 11; pitch of teeth, 1.5625 in.; diameter of pitch circle, 5.5 in.; depth of teeth, $1\frac{1}{8}$ in.; diameter of spindle, $1\frac{1}{2}$ in.; pump capacity per revolution, 172 c. in. or 0.1 c. ft.

†From the 12th Annual Report of the Victorian Country Roads Board.
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In designing the machine, the following were the rates of application of tar or bitumen aimed at:—

Work	Quantity—gal. per. sq. yd.				
Surface spray roads, 12-ft. to 20-ft. width in two strips	0.20	0.25	0.33		
Penetration on 5-ft. width				0.75	1.00

The following rates of application have been found possible, with the gear wheels appropriate for each:—

Work	Quanttiy—gal. per sq. yd.					
Spray in two strips—						
20-ft. road	.50	.40	.31	.21		
18-ft. road		.46	.36	.25	.19	
16-ft. road		.51	.40	.27	.20	
15-ft. road		.56	.44	.29	.22	
12-ft. road			.54	.37	.28	.21
Penetration on 5-ft. width	1.00	.78				
Gear wheels to be used	64–16	60–20	54–26	46–34	40–40	34–46

The capital cost of the new machine is £1,051/15/-, and the charge for hire to the various works controlled by the board is 70/- per diem, which includes wages of driver and operator.

The Method of Spraying the Surface.—The tar or bitumen is heated to 280 deg. F. (tar) and 350 deg. F. (bitumen). It is then pumped into the spraying machine by a hand pump attached to the heater, screens being provided at the foot of the pump and at the inlet to the sprayer tank to prevent foreign material entering the machine.

The machine travels under its own power to its position on the road, and before beginning to spray, the pump, piping, manifold and jets are heated by blowing through them superheated steam. The sprayer then travels along the road, which has been previously swept with both horse and hand brooms, and applies the tar or bitumen over half the width. An operator travels on the rear of the machine to operate the pump clutch and to attend to the manifold and jets.

The tar or bitumen is covered with gravel or screenings and rolled. There is no provision for keeping the tar or bitumen in the sprayer hot, but this is unnecessary, as it is possible to travel up to 4½ miles from the depot with bitumen (and further with tar) without appreciable loss of temperature before commencing work. After finishing spraying, the pump and other parts are immediately cleansed with superheated steam and washed out with tar oil.

When attended by two 800-gal. heaters, a sprayer can distribute four loads per diem provided the lead is not more than 4½ miles. This allows the treatment of 6,000 ft. of 20-ft. road a day, or 6 miles a week, given fine weather.

Quantities of Material Used.—For the first coat on a road not previously sprayed, distilled tar is used at the rate of 0.25 gal. per sq. yd. For subsequent coats 65-penetration bitumen is used at the rate of 0.2 gal. per sq. yd. Screenings or clean gravel are required at the rate of 1 c. yd. to 80 sq. yd. of road, any surplus material after covering the road being retained for feeding the road surface during subsequent warm weather.

Worked out on the above figures, the quantities of material required are as follows:—

Road Width	Tar Gal. per mile	Bitumen Tons per mile	Screenings C. yd. per mile
15 ft.	2,200	8.1	110
16 ft.	2,350	8.7	117
18 ft.	2,650	9.8	132
20 ft.	2,950	11.0	147

Tar Oil—
1 drum (40-gal.) to every 20 tons of bitumen.
1 drum (40-gal.) to every 120 drums of tar.

Engineers using these materials will find the following approximate figures useful:—Bitumen: 216 gal. per ton; 1 barrel contains 35 gal.; 6 barrels per ton. Tar: 1 drum contains 40 to 44 gal.; 1 drum when full weighs 5 cwt.; 1 drum when empty weighs ½ cwt.; 28 to 30 drums fill one 10-ton railway truck.

The cost of this work, when well organised and reasonably close to the source of supplies, is at present about 4.5d. per sq. yd. for bitumen spraying and 5.0d. per sq. yd. for tar spraying.

Penetration Work.—The machine is filled with bitumen as described above and the manifold so arranged that it sprays on a 5-ft. width, the edge of the spray being outside of the line of the wheels so that junction may be made in the previous strip sprayed without the wheel travelling on the completed work, care being taken not to overlap the previously sprayed strip. On any one section, four trips are necessary to complete 20-ft. width of road.

For this work to be successfully carried out, the lower course of metal must be thoroughly sound and firm, the upper or penetration layer of 3-in. consolidated hard clean stone free from small material, and well rolled before penetration. In these circumstances the sprayer disturbs the metal very little when travelling 2-3 miles per hour and the bitumen is forced through the entire depth of the course. The machine is capable of treating 1,200 lineal feet of 20-ft. road per diem at the rate of 1 gal. a sq. yd. The machine in operation on penetration work is shown in Fig. 2.

Bituminous Emulsions

Mr. W. Calder, chairman of the Victorian Country Roads Board, stated in his report on a visit to Europe and America in 1924, "The new

road material consists of an emulsified form of pure bitumen, which possesses the valuable quality of being capable of application in a cold form at all times of the year, and under all conditions of weather. The emulsion is a coffee-colored liquid contained in barrels of 42-gal. capacity. It is therefore of a distinct value as a commodity in the hands of road authorities for urgent repair work which could not be carried out with the class of bituminous materials that it is necessary to apply hot, and which cannot be successfully laid in wet weather. It is considered that 'cold spray' should be a great boon to municipalities not in a position to acquire an extensive plant for drying and mixing hot bituminous mixtures. Being impressed with the possibilities of its usefulness, I obtained a quantity in Great Britain from two different manufacturing firms and forwarded to Melbourne for testing purposes."

There are also on the market some other preparations which possess the first property but not the second—they are bitumens fluxed to fluid consistency with a volatile flux which upon exposure to the atmosphere evaporates and leaves the original bitumen. The board is now investigating these preparations but up to date no results can be reported.

The trade names of the emulsions tested are "Coldspray" and "Coldfix" respectively, and both were tested on the Prince's Highway, city of Footscray and shire of Braybrook, on a short section of road which carries heavy traffic comprising numerous private motor cars, considerable horse traffic and heavy industrial automobiles, some of the latter being large motor lorries conveying metal from the numerous local quarries.

Coldspray: Penetration Work.—In October, 1924, a length of 500 ft. of 16-ft. road was scarified, re-shaped and rolled, after which 4½ in. (loose depth) of 1½-in. metal was spread, rolled, and penetrated with coldspray at the rate of 1.6 gal. a sq. yd.; the surface was covered with ¾-in. screenings and again rolled. After allowing a day for the emulsion to dry out it was rolled, but it was found that the road would not consolidate properly. A further coat of the emulsion was applied (0.73 gal. a sq. yd.), covered with toppings and rolled, and thorough consolidation was then obtained. The total amount of emulsion applied was 2.3 gal. a sq. yd., but the amount of bitumen in the road is not more than is usually used on penetration work.

It was found that the emulsion had to some extent broken, i.e., the bitumen and emulsifying agent had partly separated on the long sea voyage. After three months' traffic in the summer the surface was carefully inspected and found to be in good order except for a few small waves on the side of the road which carries the heavy metal wagons fully loaded. The surface stones were exposed to wear and a sealing coat appeared advisable.

The cost of Coldspray was 1/7 a gal. landed at Melbourne—made up of 10d. a gal. initial cost in England and 9d. a gal. shipping and freight charges. The cost of the work described was 6/7 a sq. yd., made up as follows:—

Metal, screenings, etc.	22d.
Coldspray	44d.
Labor	9d.
Plant	4d.
	79d. = 6/7

Seal Coat Work.—A section of 1,340 ft. of road 16 ft. 6 in. wide, which had been resheeted with penetration macadam was sealed with the emulsion at the rate of 0.25 gal. a sq. yd. and bluestone toppings at the rate of 1 c. yd. to 119 sq. yd. of road surface. The barrel was mounted on a small truck and the liquid run out on to the road near the centre and allowed to flow towards the edge of the road, even distribution being obtained by sweeping with brooms. Owing to the fluidity of the material the quantity applied was about the maximum possible in one coating. The cost per sq. yd. was 6.5d., of which the Coldspray costs 4.75d. After six months' wear this surface was in excellent condition and appeared to wear quite as well as the ordinary seal coat of bitumen applied by the board's mechanical sprayers.

Patches.—Some of the material was used in ordinary maintenance patching, and the patches were found to hold well and withstand the effect of the heavy traffic.

Coldfix.—This material is supplied in two grades, "Grout" for penetration and "Spray" for sealing work.

Penetration.—In February, 1925, a length of 311 ft. of 16-ft. road was resheeted with 4½-in. (loose depth) of 1½-in. metal penetrated with this emulsion. The original surface was not scarified, but was patched with tarred screenings to obtain an even surface. After spreading and rolling the metal the emulsion was applied at the rate of 1.9 gal. a sq. yd. Screenings were then spread and the sheeting well rolled. The cost of the emulsion landed at Melbourne was 1/5 a gal., made up of 11d. a gal. initial cost in Scotland, and 6d. a gal. freight and shipping charges. The cost of the work was 5/1 a sq. yd., made up as follows:—

Metal and screenings	19d.
Coldfix	33d.
Labor	8d.
Plant	1d.
	61d. = 5/1

After three months it was found that the surface had not retained its shape, and considerable waving had occurred on the side carrying the heaviest traffic.

Widening Geelong Road

In his report on the investigation of road problems in Europe and America during 1924, Mr. W. H. Calder, chairman of the Victorian country roads board, said: "With the great increase in the volume of motor traffic several of the main roads leading from Melbourne, such as the Geelong road, Point Nepean road, and Ballarat road, have become too narrow to serve the great volume of motor traffic with safety. This also causes excessively costly maintenance owing to the fretting away of the edges of the pavement. Thus the repairs on the margins amount to 33 per cent of the total maintenance cost."

The system of widening such roads, as practised in Maryland and other of the United States of America, would be applicable in the instances mentioned, viz., the widening of these roads to at least 20 ft. by adding a strip of concrete 3 ft. or 4 ft. in width to one or both shoulders.

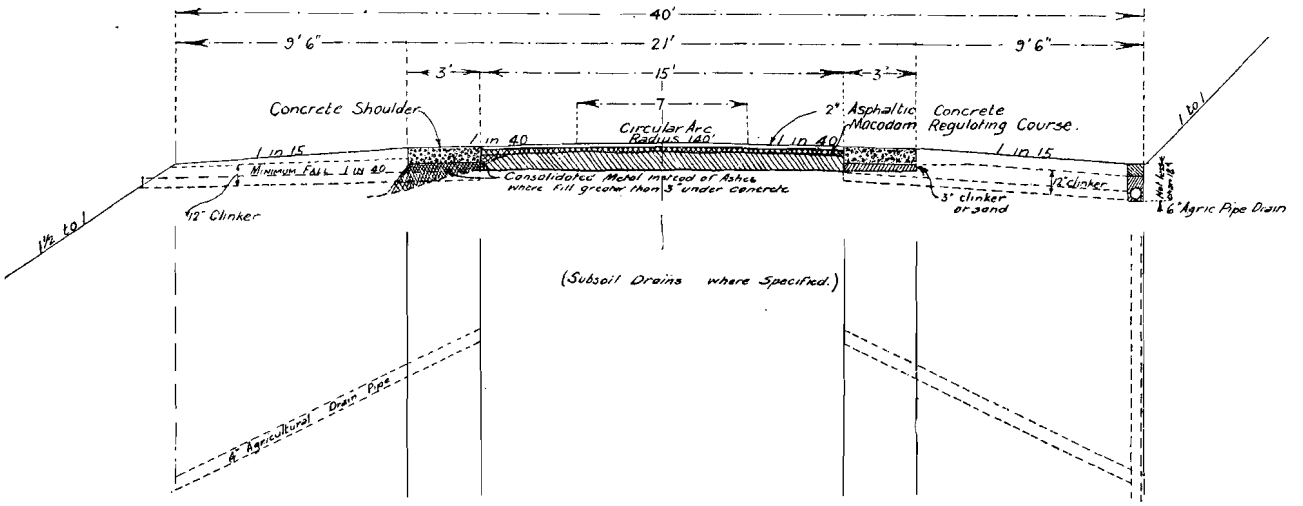

Fig. 1. Normal Cross Section of Geelong Road as Widened
The drainage where specified is shown on plan in the lower part of the figure.

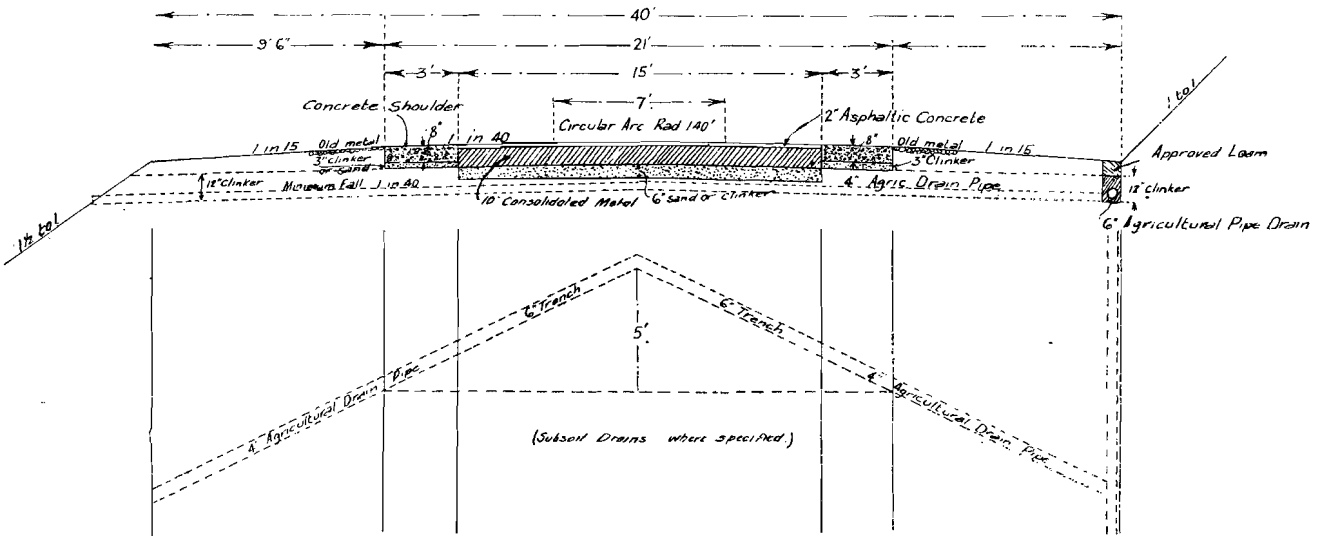

Fig. 2. Cross Section of Geelong Road as Reconstructed
In the lower part of the figure is shown a plan of the sub-grade drainage where specified.

A contract has been entered into with Victorian Roads Ltd. for the widening of 4¾ miles on the Geelong road from the Kororoit creek bridge to the Point Cook turn-off. The plans provide for the surfacing of the existing roadway with asphaltic concrete for a width of 15 ft. and the provision of reinforced concrete shoulders, 3 ft.

wide on each side of the centre strip as indicated by the transverse section, which also provides for the super-elevation of the roadway on all curves, and also for the sub-drainage of the sides and midway between the top and the bottom, and also a triangle piece for taking the tension when a weight comes on the end corner of the slab.

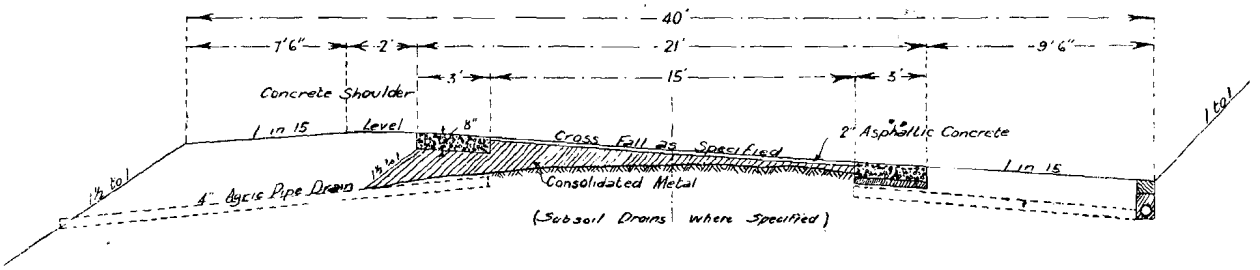

Fig. 3. Cross Section of Geelong Road on Curves

road. In some cases the roadway will have to be wholly reconstructed (Fig. 2). The concrete side slabs are made in 50 ft. lengths with two longitudinal steel bars for reinforcement at the

The work is at present in progress, and approximately 1½ miles has been completed on one side only. Owing to adverse weather conditions progress will be slow until the end of this month.

The Christchurch, N.Z., Public Utilities Committee

A Suggestion Worthy of Emulation

As a result of conversations between the mayor of Christchurch and the city engineer during May, 1925, regarding the continued trenching of the city's highways by the various public authorities and others having statutory powers, it was considered eminently desirable that steps be taken in the interests of all concerned to co-ordinate as far as possible all such operations for the future. A committee was duly constituted comprising representatives of the city council and the surrounding municipalities, the drainage board, fire brigade, the gas company, government public works department, and the post and telegraph department. The mayor is the chairman and the city engineer, vice-chairman. The committee is simply an advisory body, formed with a view to submitting recommendations from time to time to its representative authorities relating to matters of joint interest concerning the public utilities of the city and its environs. The scope of its activities and aims are as follows:—

(a) The periodical comparing and co-ordination as far as possible of all programmes of work of each respective representative body, with a view to economising the public monies by avoiding overlapping wherever possible in trenching and making good the public streets.

(b) The consideration of all questions of mutual advantage connected with the existing methods as between the representative bodies in their dealings with one another, so as to ensure economy and despatch as much as possible in all inter-related procedure and works.

(c) To carefully consider and advise all or any public body concerned who may submit any problem or question having a common interest to all parties.

(d) To make suggestions and devise means to avoid unnecessary expenditure by hearty co-operation of all members of the committee in their respective spheres of activity when planning and executing public works.

(e) To cultivate and foster as between one another a spirit of mutual assistance, respect, consideration, courtesy, and esteem such as will conduce to the best interests of the public services represented.

(f) To ensure all aspects of a subject and the view of all members being considered simultaneously by representatives of the interested bodies, thus ensuring a better appreciation of the requirements and difficulties of one body being known to the officers of other bodies when related matters are being put before the respective authorities.

Meetings are held monthly or oftener if required.

Amongst the many subjects considered at the various committee meetings held last year were the following:—

(1) Identification of Poles.—It was decided that the present system of numbering was sufficient for the purpose of distinguishing the ownership of the poles along the public thoroughfares.

(2) Concrete Slabs for Footpaths.—It was agreed to recommend the adoption at a favorable

opportunity of a standard Portland cement concrete slab 2 in. thick and either 2 ft. or 1 ft. square. The consensus of opinion was that such slabs can be easily lifted when it is necessary to open trenches, and replaced with a minimum of damage to the footpaths. They are superior to other monolithic ones and have a much longer life than either tar or bitumen with an almost negligible maintenance cost.

(3) Poles at Rounded Corners.—No decision was arrived at, it being felt that each case would have to be dealt with on its merits.

(4) Fallen Live Wires.—The urgent necessity for the public being enabled to communicate direct day or night with one central telephone number was urged. This system has now been adopted by the post and telegraph department throughout the Dominion.

(5) Common Datum for Levels.—The N.Z. Society of Civil Engineers was requested to approach the government with the suggestion that there should be one common datum throughout the Dominion.

(6) Public Services Under Footpaths.—This matter is still under consideration. Owing to the narrow width of the footpaths and the fact that the electric light and telegraph and telephone conduits are already laid on opposite sides of the streets, there is little space available for other services.

(7) Standard Survey Stones.—The necessity of protecting these during street operations was emphasised.

(8) Trenches and their Reinstatement.—Programmes are submitted monthly to the committee for discussion and comparison for co-ordination and co-operation. The city engineer of Christchurch (Mr. A. R. Galbraith) is preparing a comprehensive report with the object of evolving a scheme acceptable to all concerned for uniformity of practice.

The report concludes with the statement that during the past year approximately 43 miles of streets in the city area, or 17.75 per cent, have been trenched for roads, water supply, drains, tramway tracks, electric cables, telegraph and telephone conduits, and gas mains. This work is likely to continue for several years before conditions become normal again. With the increasing experience of the beneficial results evidenced by the working of the committee, there is not the slightest doubt that further valuable economies will accrue from the continuation of its activities.

Construction of Water-bound Roads on Clay Foundations

By W. A. Wiseman, B.C.E.*

Experiments on the roads in the shire of Donald, Vic., have shown that gravel, if suitably graded, is more satisfactory than screenings for crushed bluestone for a foundation course, and crushed bluestone and gravel for a wearing course and binder respectively, the shrinkage

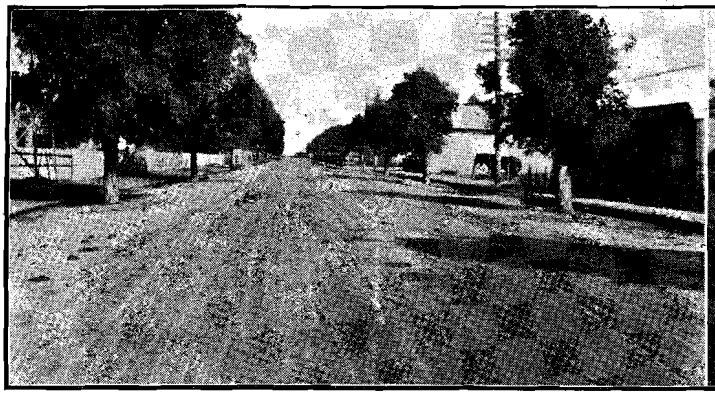

Fig. 1

Fig. 2

the binding in a water-bound road. The problem met with in the shire is that in most parts the road foundation is very clayey and shrinks excessively during hot dry spells.

It was found that if the waterbound roads were constructed in the usual way with large loosened the foundation stones and allowed the binder to work through to the foundation, thus causing the surface to unravel. To prevent this, the foundation course was put down with 5 in. of gravel similar to that used as a binder. Tests of this type of road were found to be entirely satisfactory (Fig. 1). This type of construction

*Coates and Co. Pty. Ltd., Melbourne.

is now being used throughout the shire, with the following variation, which the writer believes to be unique in Victoria.

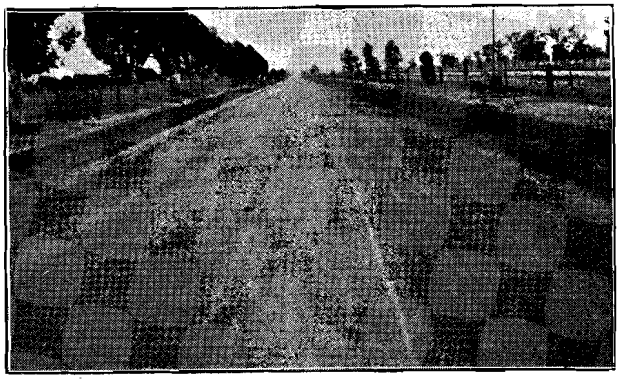

Fig. 3

The 5-in gravel foundation course is put down and allowed to consolidate thoroughly under traffic for a year or more. The wearing course and binder is then laid on the consolidated foundation. This method of construction enables road construction to be pushed forward cheaply, and rapidly, and gives excellent results, the well-consolidated foundation tending to eliminate the formation of potholes.

Fig. 2 shows a road in the course of construction. The gravel used for the foundation course in this road is a curious limestone pebble formation which, when wet, sets almost as hard as lime mortar under traffic. The formation occurs as a ridge on the shores of Lake Bulloak. This material is too soft for a binder, but makes an excellent foundation course.

Fig. 3 shows a main water-bound road which carries comparatively heavy rubber and steel-tyred traffic, but will show no sign of unravelling.

The writer is indebted to Mr. F. W. Rigg, shire engineer, for the foregoing information.

Water Purification at Swan Hill, Vic.

On August 14 Mr. F. Brawn, M.L.C., chairman of the Victorian Provincial Towns Sewerage Authorities' Association, officially opened the Paterson Chloronome, which has been installed at Swan Hill for the purification of the town water supply through the courtesy of the Commonwealth department of health.

The plant was made by the Paterson Engineering Co., of London, for whom Messrs. Fyvie and Stewart, Melbourne, are agents. Mr. H. G. Furphy, of the Commonwealth health department, supervised the erection of the plant, and, at the official opening gave the history of water purification by chlorine. It has been established for many years in American cities, and was adopted at the Western front in the war. Chlorine is not capable of destroying all germs in water, but so purifies the water as to neutralise considerably the effects of pathogenic bacteria and bacilli.

Other officials present at the opening included Mr. F. E. T. Cobb, chief sanitary engineer of the state health commission, Dr. C. P. Rowan, district health officer, and Mr. J. M. Mathew, supervisor of testing of the Victorian state rivers and water supply commission.

Water Purification by Chlorine Gas

The sterilisation of water as chemically performed must satisfy the following requirements: 1. It is essential that the water, after treatment should be palatable, and have no harmful or unpleasant effects upon consumers. 2. It is highly desirable that the treatment should not cause any precipitate, the removal of which would complicate the process, and increase its cost. 3. The sterilising agent must be cheap and simple in application, so that its use for the treatment of large volumes of water may not entail any heavy outlay either for material or labor. 4. The plant necessary for its application must not only admit of sensitive and accurate control over its administration, but must be capable of working regularly for long periods without attention. 5. The initial cost of the installation must be low in relation to the volume of water to be treated.

Chlorine is the sterilising agent which conforms most closely with these requirements, but, prior to its introduction, it had been the practice to use bleaching powder or sodium hypochlorite. Both these methods, however, are open to the objection that the reagent contains only a small proportion by weight of available chlorine, so that large quantities must be used to attain the desired result. In addition, the former substance is unstable, and the proportion of chlorine which can be made available is rapidly reduced in warm and moist climates.

Further, it is essential that the bleaching powder be mixed in paste form before addition to the water. Pure chlorine can, however, be obtained in gaseous form, and is entirely free from the objections given above. It is a reagent in a state approaching absolute purity, and as it contains 100 per cent available chlorine its

whole weight is available for sterilising purposes. It is now produced in large quantities at low cost, and is supplied compressed to a liquid state in steel cylinders. The reaction which occurs is expressed by the equation:

$$2Cl_2 + 2H_2O = 4HCl + O_2$$

Nascent oxygen is liberated, and it is not improbable that the chlorine itself has a direct toxic effect upon the organisms apart from the production of oxygen.

The design of a suitable apparatus to apply chlorine gas with precision, resolves itself largely into producing a mechanism which is unaffected by the virulently corrosive properties of chlorine upon metals in the presence of moisture. The "Chloronome" (the registered name of the Paterson Engineering Co.'s device for regulating, measuring and administering chlorine gas to water supplies), has the unique feature that it interposes between the metallic parts of the apparatus and the absorbing water supply, an isolating column of liquid unaffected either by the gas or the absorbing water, thus ensuring that the chlorine gas in contact with the metallic parts of the apparatus is dry and free from any corrosive tendency.

The Chloronome consists essentially of a means for conducting the gas from the storage bottles to the instruments for the reduction of pressure and regulation, so that the gas is administered at constant low pressure, and for the exact measurement of the gas, its application and distribution throughout the entire body of water to be treated. Two types have been designed, the Pulser type, Fig. 1, dealing with small to medium supplies, and the Manometer type[1] with large supplies.

Fig. 1 shows a typical arrangement of apparatus. The liquid chlorine is contained in a steel cylinder from which it passes into gaseous form on evaporation by the heat abstracted from the atmosphere through the walls of the cylinders. These latter are usually placed on a weighbridge for checking purposes. A coil connector valve is coupled to the valve on the cylinder head.

The chlorine gas is led through a flexible connecting coil of copper tube to the filter, which removes any slight deposit carried by the gas from the exposed coil tubes or cylinder fittings.

Two pressure reducing valves are arranged in series to maintain a constant pressure of gas on the regulating valve. From the regulating valve the gas passes to the meter (to which later reference is made in detail), thence through a central pipe down nearly to the bottom of the glazed absorption tower, which is fitted with a water distributing tray, and packed with pumice. A small trickle of water is uniformly distributed over the pumice, and in its downward flow absorbs the measured gas. The chlorinated water flows from the bottom of the tower through a chlorine resisting rubber pipe or earthenware pipe, and is uniformly distributed through the main body of the water to be disinfected.

The Chloronome pulsing meter consists essentially of a U-shaped tube with a connecting branch between the two limbs. This tube contains sulphuric acid which acts as an inert seal between the dry chlorine gas in the instrument, and the absorbing water supply. The flow of gas into

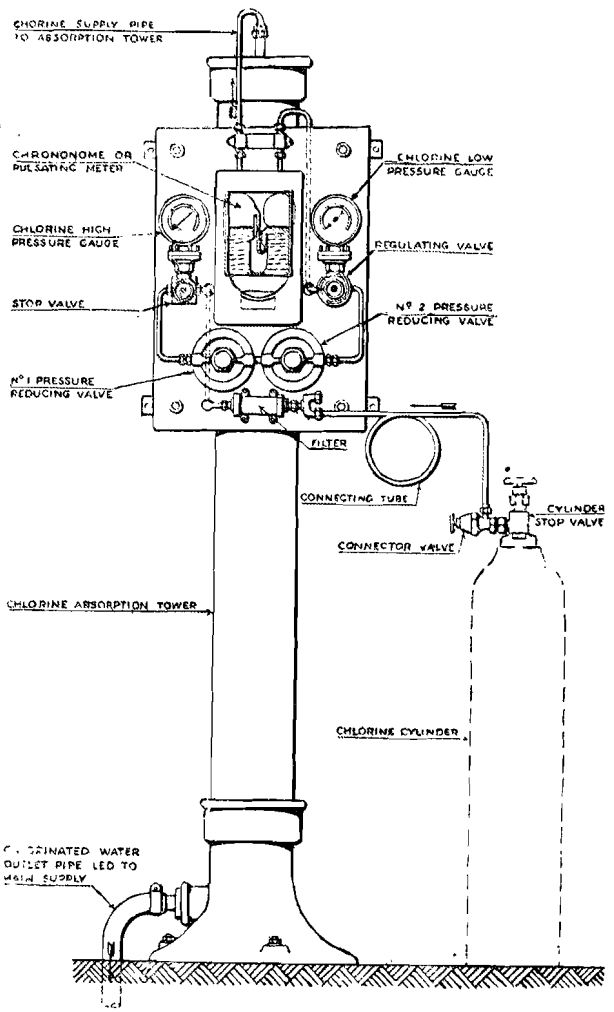

Fig. 1. Paterson "Chloronome"—Pulser Type

the inlet limb depresses the column of sulphuric acid until it unseals the small vent pipe, so permitting the passage of the measured quantity of gas from the inlet to the outlet limb. This establishes equilibrium, and allows the return of the column of sulphuric acid until it again seals the vent pipe, when the cycle of movement is completed, and another downward stroke commences. The rate of pulsation and known volume gives the weight of chlorine added. Prolonged tests have shown that when the regulating valve is once set the meter continues to pulse for months at the same rate.

1. Described in the "Commonwealth Engineer," February 1, 1925, pp. 249 and 250.