Within the limits of a short paper such as this, it would be obviously impossible to describe, in anything approaching a complete story, the building of a modern organ. I shall therefore confine my remarks to the main principles involved, and to such details as may be considered of use to the engineer.

If the subject is an unusual one, I hope that it may at least create a diversion from the usually very solid subjects dealt with by my more intellectual fellow members.

It used to be said that an organ was a bad imitation of an orchestra, but the modern organ now contains exact replicas of every kind of tone found in an orchestra as well as many other effects, and it has therefore a good case for being called the "King of Instruments."

Unlike all European countries and America, Australia is not yet organ-conscious. In a city of the size of Melbourne, for instance, we ought to be able to count our organs by the hundred instead of by the dozen. In England and America, almost every little church has its pipe organ.

We have, however, the consolation of having one of the world's famous organs in our Town Hall in Melbourne, and at this time, when the world's most famous organist is visiting us, there is perhaps a slightly increased interest in this truly wonderful instrument.

The history of organ building is lost in the mists of time, but can be said to have commenced when the first roughly-cut flute was made and blown by man. It was found that by cutting holes at varying distances from the mouthpiece it was possible to play different notes with the same pipe. There were two main types of flutes, one which was blown from the end, as the ordinary tin whistle, and the other which was the prototype of the orchestral flute which is held sideways.

The next stage was the discovery that two of the former type could be blown together and played by one performer. The pretty effect of this two-part harmony gave a fillip towards further possibilities.

Then comes a gap of two or three thousand years, during which much progress was undoubtedly made, and the information lost. We know this to be so, for during the excavation
work at Pompeii there was discovered the remains of an hydraulically blown pipe organ.

However, as far as we are concerned, the next step was the placing of several pipes on a box of wind. The pipes were made to speak or be silent by the pulling backwards or forwards strips of wood which controlled the air to the pipes. Only one note could therefore be played by one hand, and the bellows was of the type we used at one time to encourage fires. The pipes could speak only when the bellows was actually delivering air, and the organ was silent during the opening of the bellows, a condition which was not entirely satisfactory.

In an old Saxon psalter we find a picture of a much improved organ. Two players and four blowers were operating the instrument. The two players would give four-part harmony, and the four blowers would have an excellent chance of sustaining some semblance of a continuous wind supply.

The organ as an instrument could not proceed far without an adequate continuous wind supply of even pressure, and this was accomplished when the weighted reservoir was invented, and occupied a position between the bellows and the wind chest. The sliding strips were replaced by valves controlled by a rough sort of keyboard. True it is that these keys were sometimes of ornate design, but the mechanism could not have been very efficient, for it is recorded that they required operation by a closed fist. The organist was known as an “organ beater.”

From the eleventh century these heavy and large keyboards gradually changed in size and design, until the modern keyboard was evolved, and for hundreds of years the organ changed little in form.

Let us consider now the old type of tracker action organ. Probably about 60% of the world’s small organs are of this type.

The general principle of the tracker action organ is that the tail of the key operating through a series of wooden levers and rods opens a pallet (or valve), which supplies wind to the pipes on the wind chests. The latter are large boxes on which are arranged the pipes which produce the sound. The lower portion is a large common box, which is connected to the wind supply. The upper portion is divided into as many narrow chambers as there are keys in the keyboard (generally 61) or pedal board (generally 32). The pallets control the air from the lower chamber to these upper chambers. Above the latter there is a series of pipes, each of the same note but of a different
tone quality or pitch, and each or all of these can be made to speak or be silent by the following means:—

The top of the soundboards is covered by triple layers of cross members, the top and bottom layers of which are fixed to the wind chest. The centre strips are sliders—one to each quality of tone (Diapason, Flute, Trumpet, etc.). These cross members are all drilled together at a pitch equal to that of the small chambers.

When the slider is in such a position that the series of holes in it is in line with those in the top and bottom cross members, then it will be seen that, if a pallet be opened, the pressure air from the lower chamber can enter the pipe and make it sound a note. Those sliders, however, which are not in line prevent air from entering the pipes above them, and the stops are off.

Each slider controls air to a set of pipes of one tone quality, and is operated through levers and rods by a stop knob at the keyboard.

The pipes are “planted” in a special way on their sound boards. The largest pipes are placed at the ends, tapering to the smallest in the centre. Thus C, D, E, F sharp, G sharp, etc., is the order from one side, whilst that from the other is C sharp, D sharp, F, G, etc. This is done for two main reasons—

1. The better distribution of weight. The wind chests are heavily loaded beams supported at their ends (by the building frame) with the heaviest pipes nearest the points of support, and the smallest pipes of negligible weight near the centre. This is an ideal method of loading.

2. The prevention of any possibility of the larger pipes robbing wind from the smaller.

As the pipes for the bottom two notes are approximately 7 to 8 feet apart, and this alternation continues on a gradually reducing scale, the method of connection between key and pallet is really simpler than one might suppose.

It consists of a board fitted with wooden rollers of varying lengths with steel end spindles in wooden bearings. Near each end of each roller is a short metal arm, one of which is directly over the tail of the key, and the other directly under the pallet and connected by wooden rods about ¾ in. square, each fitted with approximately 16 gauge screwed wire. Small leather buttons act as nuts, and felt washers complete a noiseless and efficient adjustable connection. Compression rods are called “stickers” which, if long, are often centrally guided to prevent bending. Tension rods are known as “trackers.”
The greater the number of stops, the larger must be the pallet to admit air when all the stops are in use.

As the pallet must be lifted against the wind pressure in the lower chamber, a large organ requires a strong man to play it. Thus the size of organs was strictly limited. For the larger pallets a small section was fitted which considerably reduced the power required by the organist. This section opened immediately before the remaining large section.

In 1827 Josiah Booth, of Wakefield, fitted puff bellows to help open the large pallets in the organ at Attercliffe Parish Church, Sheffield.

Then the pneumatic lever was invented in 1832, and, although Mr. Hamilton, of Edinburgh, was a claimant, it is generally conceded to Charles Spackman Barker, and it is, therefore, known as the “Barker” lever.

In this invention the depressed key opened a small valve admitting air to a motor bellows which, in turn, opened the pallet. On the key returning to its normal position another valve was opened to atmosphere to exhaust the bellows, whilst at the same time pressure air was cut off. Thus all the work was done by the blower boy, for this was long before the advent of electric motors or even gas engines.

The “Barker” lever was perhaps the most epoch-making invention in the history of organ building.

The motor bellows, of course, must be of larger area than that of the pallet if worked by the same wind pressure.

As usual, Barker, being an Englishman, could not persuade the English builders to try it, so he went to France, and the great French organ builder, M. Aristide Cavaillé-Coll, immediately applied it to the grand organ for the Church of St. Denis, and it became his standard action, after which the English builders began to use the idea.

These early actions were unfortunately noisy. Mr. Henry Willis, after seeing an organ at Paris Exhibition in 1867, in which the action was operated by compressed air in tubes, began experiments in tubular pneumatic action, and produced the then wonderful divided organ in St. Paul’s Cathedral, London, operated on the pressure system. The variety of tubular pneumatic actions is endless, but later types generally exhaust the motor bellows which is inside the wind chest, and this makes for quietness.

William Sturgeon discovered the electro-magnet in 1826, and his friend, Wilkinson, of Kendal, experimented with the idea of applying it to organ action work, but seemed to have had
little luck, mainly because of battery difficulties. Dr. Gauntlet (of hymn tune fame) experimented and actually took out a patent in 1852 for a magnet to open the pallets of organs.

Karl Weizle built several organs on this principle, but they appear to have been unsatisfactory.

Meanwhile, French scientists—Du Moncel and Fromont—considered this control, and in 1850 a somewhat unreliable instrument by Stein was on view at Paris Exhibition.

Dr. Albert Peschard (1836-1903) put electro-pneumatic action on a sounder footing, and he took out a patent in 1864.

Barker and Peschard took out a joint patent in 1868 of which Bryeason Bros, of London, acquired the manufacturing rights, the first English electric organ being built for Drury Lane Theatre, London, the console being 50 feet away. This organ was a reliable and successful instrument.

In 1886 Mr. Robert Hope-Jones came on the scene, his first organ being built for St. John’s Church, Birkenhead. He was an electrical engineer, and he has probably done more for organ building than any other person. He was a genius. Perhaps his ideas on certain matters were at the time too advanced for England. At any rate he went to America, where he became associated with the Wurlitzer Company, and devised the “unit orchestra,” the precursor of the modern cinema organ. His first attainment was the reduction of electric power to only a very small fraction required previously, so that his usual power supply was three large dry cells for a medium-sized organ.

The writer knew the magnificent small Hope-Jones two-manual divided organ at St. Paul’s Presbyterian Church, South Shields, at which Dr. W. G. Whittaker presided for many years. It was built in 1894, and had double touch, double power, stop switches, 61 notes, complete electric console, took up no floor space, except the console in the centre of the church amongst the pews. The organ itself was built on the wall at either side of the pulpit.

There have been many types of wind chests invented. Some of these have been eliminated because of unreliability, for reliability is absolutely essential in organ building. Thousands of organs all over the world are giving good service after 50 years, even with practically no maintenance whatever—not even lubrication. 

There are several types of very efficient sliderless wind chests, which are more reliable in hot climates than the slider type. Most of these have a valve for each pipe operated by
a small bellows in a separate air chamber for each stop. The small bellows for each note are connected together by grooving to a control valve.

The separate air chamber for each stop can be filled with pressure air by drawing the stop knob or emptied by the reverse process.

When a key is depressed the air grooves are connected to atmosphere. Those small bellows which happen to be connected to the air chambers containing pressure air will collapse, and by this means open the valve to admit the air to the pipes above them, thus making them speak.

One excellent type is that in which the wind chest is a room which can be entered by double airtight doors, and by which means adjustments can be made whilst the organ is actually in use. The pedal pipes are often so scattered that separate wind chests for each stop and magnets for each pipe are provided.

The church or concert hall instrument has 2, 3, 4, or even 5 manuals and a pedal board. The keyboards are arranged in a definite terraced order.

In a two-manual organ the bottom keyboard controls the great organ, and the upper manual controls the swell organ, because that section is in a more or less sound-proof box, with one or more sides fitted with a set of pivoted shutters very similar to that of a venetian blind. By means of a pedal the organist can open or close these shutters to increase or decrease the intensity of sound.

On a three-manual the Choir Organ keyboard is placed below that of the Great Organ. On a four-manual the top keyboard is added and controls the Solo Organ. In modern organs these two are also in swell boxes. In the case of the Melbourne Town Hall organ, a large portion of the Great Organ is also enclosed.

The pedal board is a 32-note keyboard for the feet, but to a larger scale to allow of the toes and heels of the organist to play notes separately. These are now made radiating and concave to make all keys equally easy of access by the feet.

The lowest note on keyboards and pedals is always "C," and corresponds to the note which is 15 semitones above the bottom note of a piano. Modern organs have 61 notes on the manuals (5 octaves).

As previously mentioned, each key can play each or all of the different pipes of the same note by means of the use of stop knobs. Further, coupling mechanism enables the organist to play also other keyboards than the one on which he is playing.
In many instances he can play certain other keyboards an octave higher and/or lower.

The pedal board controls its own department, and can also be coupled to any or all of the manuals.

The stop knobs or stop keys are of varying designs, and are arranged in groups belonging to their respective departments.

In the old type tracker action organs the stop knobs are connected by levers and connecting rods to the slides which they operate.

In the pneumatic-action organ the stop knobs or stop keys control the air to the motor bellows which operate the sliders.

In the electric-action organ the console is an elaborate switch-board, in which the keys, stop knobs, or stop keys and the pedals are the controls. No air whatever is at the console, which can, therefore, be at any distance from the organ so long as it is connected by the cable.

The basis of the modern electric action is little changed from the days when Hope-Jones invented his system. The electromagnet is a small horseshoe type about 2\(\frac{1}{2}\) in. long and of approximately \(\frac{3}{8}\) in. iron wire at about \(\frac{1}{3}\) in. centres wound with fine enamelled wire. This magnet operates a small valve about the size of a 3d. piece. The lift of this valve is only about \(\frac{1}{16}\) in. Its purpose is to control high-pressure air from the magnet chamber to pass to a small motor bellows which, in turn, operates the main pallet, slider operating bellows, or other control, mostly per medium of intermediate motor bellows, which are of all shapes and sizes.

Electro-pneumatic action is rapidly ousting the purely tubular-pneumatic action, partly because of its speed and reliability and partly because of cost. In other actions the whole organ must be completely assembled in the shop, dismantled, and reassembled in its final position.

With tubular-pneumatic action hundreds of lengths of lead composition pipes must be accurately cut to length, bent to shape, and correctly marked, dismantled and reassembled on the job.

The electrically-operated instrument is only connected to its console by a cable of sufficient length, which is of negligible weight and cost compared with the lead pipe connections of the purely tubular-pneumatic action instrument. Electric action is practically instantaneous, whereas with purely tubular-pneumatic action the whole length of the pipe connection must be filled with high-pressure air before the valves at the organ can respond to the wishes of the organist at the console.
actions are necessary for distances over 20 feet or so, otherwise the action is slow.

Two systems are available for the pneumatic part of the instrument—one in which the operation is accomplished by means of air pressure and the other by exhausting the air pressure. These are known as the pressure and exhaust systems.

The coupling system was elaborate in many instances. Wherever the distances were short, these connections were until recent years, for the most part, purely pneumatic, the electrical connection only being used for long distances, but rapid strides in simplified electrical controls have almost ousted pneumatic coupling in electric organs.

In the case of super and sub-octave couplers, the control was often by means of sliders in a small wind chest, which opened or closed pressure air to a set of pneumatic tubes connected to notes an octave above or below as the case may be. In modern organs, however, these are also operated by simple electric connections.

Electric action in the early days was troubled with dirty contacts, which caused missing notes.

Some of the earlier types employed mercury cups into which wires dipped to establish connection, but Hope-Jones solved the problem by making contact by a wiping motion between wires placed vertically so that dust would not settle on them. The wiping motion ensures a bright, clean contact. To-day the same principle is adhered to, but points are sometimes platinum tipped, and the use of nickel strip or wire is extending for this contact work.

Wood is used for lightness of moving parts, and the lubrication used is usually graphite.

The workmanship of a modern organ is really of a very high order, and would surprise most engineers.

Organ builders must be as a rule the most patient men in existence, and they are for the most part real enthusiasts for their work.

The Pipes, etc.

Pipes are of three kinds—flue, reed, and diaphone. The former are numerically much the larger in any organ, and they are made of metal or wood. The metal pipes are of circular section, whilst the latter are square or oblong. Different qualities of flue tone are obtained by means of alterations to the mouth, relation of length to section, the section itself, thickness of metal, and the wind pressure, whilst the addition
of a stopper to close the top end of a pipe lowers its pitch an octave and alters its quality.

Total quality is a tremendous subject, and in a general paper of this type could not be given any more than a few brief notes.

The foundation tone of the organ is diapason, and is produced by pipes of the kind mostly used on the front of an organ case. As a general rule these few front pipes are speaking pipes, and are supplied with wind through a tube taken direct from the wind chest to which it rightly belongs.

There is no such thing as a pure fundamental tone in organs, as every kind of pipe produces some harmonics or overtones, even though they are in some cases only slightly audible.

The nearest approach to pure fundamental tone is that produced by the Stopped Diapason or Bourdon, and is almost colourless because of its lack of harmonics.

There are three main classes of tone produced by organ pipes. Diapason tone is produced by such stops as:

Open Diapason .. Wood and Metal.
Principal .... Metal
Gemshorn ...... Metal
Twelfth ...... Metal
Fifteenth .... Metal

Gamba or String tone is produced from stops, such as:

Various kinds of Gambas.
Viol d'Orchestra.
Vox Celeste.
Vox Angelica, etc.

Flute tone is produced by various stops of that name:

Wald Flute.
Harmonic Flute
Zanber Flute, etc.

There are, of course, many stops found in organs which are intermediates, such as:

Rohr Flute.

This stop is made to produce an upper harmonic which renders its timbre flutey in character, but at the same time the fundamental tone is sufficiently obvious to link it with a Stopped Diapason.

The reeds are a class by themselves, but can be divided into classes in a similar manner:

Trumpet Clarionet
Horn Vox Humana, etc.
Oboe
The Diaphone is a valvular reed, and in a class by itself.

Before any pipes are made the whole ensemble tone of an organ should be considered, and the different qualities of tone in their correct ratio decided upon.

Then the scale (or relation of length to section), thickness of metal, and the rough shape of the pipe's mouth for differing qualities of tone is fixed, and the pipes are made. After this the voicer takes charge, and they leave his hands as finished musical instruments. Each pipe of a set of 61 notes must be of the same kind of tone, and a highly skilled voicer is worth his weight in gold. Nowadays there are specialists who concentrate on one or two types of tone only, and they each have their special methods in obtaining the fundamental and harmonics in their correct proportions to obtain the desired tone.

**Diapason Tone.**

This is the real foundation tone of a church or concert hall organ. It is the tone from which the upper harmonics have been eliminated, leaving only those which produce the grand rolling effect so often heard in old cathedral organs.

The scale of an 8 ft. diapason in churches and concert halls may be 6 or 8 inches, but for chamber organs may be as small as 4\(\frac{1}{2}\) inches. (The scale of a set of pipes means the diameter relative to length of the pipe.)

To obtain high quality tone it is considered that it should have a high proportion of tin with lead and plenty of material.

The width of the mouth varies between one quarter and one fifth of the circumference, whilst the height of "cut up" is about one third of the width.

Numerous other items, such as fitting leather to the upper lip, coarse nicking, etc., all play their part in tone production, whilst sometimes the bass notes are fitted with bars or beards to overcome speech defects and to produce string tone.

The German builder Schulz is recognised as the producer of the finest Diapasons ever made, and his best example is probably in St. Mary's Church, Tyne Dock, South Shields.

**Gamba Tone.**

This tone is opposite to that of Diapason tone. Spotted metal is the best, and the pipes are of small scale and of thin metal. To produce spots the proportion of tin and lead must be somewhere around 50-50.

The lips should be low and free from arching to eliminate the higher harmonics, whilst the edges of both languid and upper lip should be sharp.
Nicking is finely done to accentuate high harmonics. Pure stringy tone is produced by pipes of small scale.

**Flute Tone.**

In Wald and Clarabella Flutes the mouth is smaller than that of a Diapason pipe, and the pipes are constructed of wood of a rectangular section. The mouth is in the narrowest side of the rectangle.

In a Hohl Flute the mouth is on the wide side of the rectangle. Metal pipes are made from cast sheet formed on wooden rods and joints soldered. The sheets are planed by hand to thickness required.

**The Production of Harmonics.**

When an open pipe is sounding its lowest (fundamental) note, the column of air is divided into two equal vibrating parts separated by a node or place of comparative quiescence in the centre of the pipe.

By increasing the pressure of air, or by piercing the pipe at the node, the column of air may be made to break up into four vibrating parts. When this is the case, the pipe produces its first harmonic overtone. By further increasing the pressure, the column of air may be made to divide into six vibrating segments. Further increases in pressure produce 8, 10, 12, etc. Each of these fresh divisions gives a successively higher harmonic.

The number of vibrations producing the note augment in the same ratio, i.e., the ratio of 1, 2, 3, 4, etc. Therefore, if the fundamental note is produced by 64 vibrations, the first overtone will be produced by \(2 \times 64 = 128\) vibrations, representing the octave above the fundamental. The second overtone will give \(3 \times 64 = 192\) vibrations, which is the twelfth above the fundamental.

If an open pipe sounds "C," its natural harmonic overtones will be C, G, C, E, G, Bb, C, D, etc.

On account of its different method of vibrating, a stopped pipe produces different harmonics to an open pipe. Its ratios are 3, 5, 7, 9, etc., and its overtones are G, E, Bb, D, etc.

For the addition of certain harmonics to the organ, there are stops called Twelfth, Mixtures, Quint, etc. On depressing any key with the Twelfth only drawn, the twelfth above the normal note is produced. Thus, by playing "C" the note produced is actually "G" in the octave above.

The Mixture type of stop produces anything between 3 and 6 notes, all of which are added harmonics generally for use when the full organ is being used.
There is a large number of elaborate works on this subject, and for those who care to interest themselves, the production of sound waves is a fascinating subject for research.

**Material of Pipes.**

Even from earliest times organ pipes have been constructed of a tin and lead mixture. Organ builders know it as "metal," and the term "spotted metal" is a guarantee of excellence, denoting as it does a 50/50 mixture or thereabouts.

Whenever zinc is used it is specially mentioned, and its use is purely for economy only, such as in large pipes of Diapasons.

For wooden pipes, well-seasoned timbers which are close-grained and resinous seem to lend themselves best to the production of organ tone. In small pipes the use of nails is barred, the pipes being glued together and sometimes pegged with wood.

**Reeds.**

These are a different form of pipe, consisting of a boot in whose upper end is fitted a block to support a shalot fitted with a brass tongue, which vibrates against it, and which is fixed to it at one end by a wedge. Tuning is effected by means of a spring, of which the length of vibrating section can be altered. The shorter the vibrating section the higher the note, and vice versa. The tone would be weak and colourless without the resonator pipe above it. These are generally tapered.

Reeds are operated by various pressures of wind, and some modern reeds operate on 20 inches pressure, and many of these are as smooth as cream.

The Diaphone is a valvular reed, and Hope-Jones was the man who first made a success of it. They are very powerful stops, and are only found on large organs, such as that in the Melbourne Town Hall.

A vast field of research awaits its turn for investigation in this type of pipe, which is at present only used for pedal notes.

One form of Diaphone is illustrated in Fig. 35.

The method of producing sound is as follows:—High pressure air fills the left hand chamber. On playing a pedal note, the operating valve is opened, thus supplying air to the right hand chamber. The valve on the end of the spring, being a small distance from resonator supply when at rest, allows a puff of high pressure air to pass up the resonator. This puff closes the valve and cuts off the supply to the resonator, causing a rarefaction. The spring then takes charge and reopens the...
valve, allowing another puff to pass. This cycle of operation continues as long as the key is depressed. The result is a terrific volume of a peculiar penetrating sound unattainable by any other means at present.

**Synthetics.**

If the formula for a given tone quality is known (say of a trumpet or clarionet), the component parts may be obtained from other stops, and these sounded together in their correct proportions will give the required tone quality.

Some very fine examples of synthetic reeds and various orchestral tones have been produced by American and British builders.

**Percussions.**

The majority of musical percussions consist of metal (or wooden) bars placed over resonating cavities and struck by electro-pneumatically operated mallets. The action is so constructed that the mallet immediately leaves the bar after striking, in a similar way to a piano hammer after striking its string.

One new type of percussion is called the Vibraphone. Its charming undulating effect is produced by means of revolving vanes placed in the mouth of the resonators, which alternately connect and disconnect them from the vibrations of the bars.

Pianofortes when played from an organ console are either operated by means of an electro-pneumatic action or else by means of a "player" action controlled from the organ by electro-pneumatic means.

**Blowing Apparatus.**

The hand-blown organ is rapidly being replaced by power blowing.

The handle is an extension of a wooden lever pivoted in the centre and connected at two points to the two hinged feeder bellows which supply the weighted reservoir bellows, one delivering whilst the other is taking in air.

A balanced relief valve is fitted to prevent the reservoir being over-filled, and an indicator cord is taken from the top of the reservoir to end in a weight for the edification of the gentleman who supplies the power behind the scenes.

The large modern organ-blowing apparatus is generally a multi-stage fan direct coupled to a motor. This enables tappings to be taken from any or all stages, according to the
pressures required. For example, the Melbourne Town Hall organ has the following wind pressures (inches of water):

<table>
<thead>
<tr>
<th>Wind Pressure</th>
<th>Choir Organ</th>
<th>Pedal—</th>
<th>Great</th>
<th>Swell—</th>
<th>Solo—</th>
<th>Orchestral—</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flue</td>
<td>4 in.</td>
<td>4 in.-6 in.</td>
<td>6 in.-8 in.</td>
<td>6 in.</td>
<td>6 in.</td>
<td>6 in.</td>
</tr>
<tr>
<td>Reeds</td>
<td>20 in.</td>
<td>12 in.</td>
<td>12 in.</td>
<td>10 in.</td>
<td>6 in.</td>
<td>6 in.</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

The motor generally also drives a small generator to supply power for the electric action, the voltage being in the region of 12.

Stop Knobs and Stop Keys.

For hundreds of years the familiar old stop knob was used on organ consoles, and quite often the knob had a long travel to overcome the frictional resistance. It used to move directly forwards, but later organs had the stop jambs placed at 45 degrees, like those at the Melbourne Town Hall.

Pneumatic action reduced the need for long travels, and a heavy pull, thus making it possible for quicker stop changes.

Hope-Jones started the cult of stop keys which are so easily changed, readily accessible, and take up only a fraction of the room required for stop knobs. Since then quite a variety of stop keys has been designed, each with that objective.

Old methods die hard, however, and the old school of organists still prefer knobs.

Combination Pistons and Pedals.

In old organs a set of iron pedals projects from the console just above the pedal board. These were called "composition pedals," and were clumsy arrangements for moving certain groups of stops by means of the feet.

Since pneumatic action was introduced these stop group changes are made by means of thumb pistons placed conveniently below the keyboard to which the stops belong, and within easy reach of the thumb whilst playing. These are generally duplicated by combination pistons for the feet.
On a four-manual organ it can be understood that a rather imposing array of these combination pistons would be necessary, making it very difficult for the organist to find with his feet. The organist cannot afford to look down to see what his feet are doing, so a smaller number of pedals do double or treble duty.

This is accomplished by stop keys marked:—

Great Pistons to Pedals.
Swell Pistons to Pedals.
Choir Pistons to Pedals.
Solo Pistons to Pedals.
Pedal Pistons to Pedals.

By using these stop keys the combination pedals are made to operate the groups of stops instead of using the thumb pistons when the hands are too busy.

Another modern development is the Stop Control Tablet. Supposing that the organist is playing a composition where drastic stop changes are necessary at times when his hands are too busy. He first draws the stops necessary for the first portion, and then presses down the stop control. Then, before starting to play, he alters the stops to his requirements for the second movement. When he plays, he is using the first choice of stops, and not those actually showing. When the change is required, he takes the stop control off, and this immediately makes the second choice operative. By again depressing the stop control the second combination is set, and at odd times he can proceed to set his third choice. This is a very useful accessory.

Generally a series of rocking tablets are to be found in the wooden edges of the key frames. Those on the left generally control the coupler to connect the pedal notes to the manual where they are placed. On the right side the tablets often control the tremulant for the manual alongside which it is placed.

In the centre, above the pedal board, are the large balanced pedals which control the shutters for the crescendo effects. On very large organs there is usually a general crescendo pedal. By using this pedal and commencing fairly softly, the stops are added, the couplers operated, etc.—all in their proper order until full organ is reached, and vice versa.

On some elaborate organs arrangements are made whereby the stops operated by each combination piston can be selected by the organist.
**The Tremulant** is a device whereby the supply of wind to a wind chest is interrupted at regular intervals, thus producing the mock-pathetic effect beloved by the average cinema organist. A good organist uses the tremulant sparingly, often not at all.

**The Extension Organ.**

The foregoing notes have all been about what is known as a “straight” organ, in which each manual or keyboard has its own department.

A stop knob marked “Flute 8 ft.” has the same pitch as that of a piano, and is so called because the pipe producing the lowest note “C” is 8 feet long from the mouth to the top (if an “open” pipe). Similarly an octave lower would be called a 16 ft. stop, an octave higher 4 ft., and two octaves higher 2 ft. Now each of these in a “straight” organ would have 61 pipes or 5 octaves, a grand total of $61 \times 4 = 244$ pipes.

In an “extension” organ, as used in cinemas, the 8 ft. rank of pipes is extended one octave lower and two octaves higher, from which the four stops are derived, a total of only 97 pipes. The tonal result is the cause of a controversy which has been raging for years.

Obviously when a chord is played on the “extended” organ, with all the stops in operation, the tonal result is not so full as that played on a “straight” organ, but it must be remembered that people go to the theatres mainly to be amused. After all, the tonal deficiencies are possibly more imaginary than real, especially when the instrument is designed by an expert builder and played by an expert organist.

Each rank of pipe is a “unit” on a “cinema” organ, and does not belong to any particular manual. Each can be played from any manual, and this accounts in part for the huge array of stop switches of the average cinema console.

On a four-manual and pedal “Wurlitzer” organ the keyboards starting from the lower manual are usually:

- **Lowest keyboard** . . . Accompaniment group.
- **Second keyboard** . . . Great group.
- **Third keyboard** . . . Orchestral group.
- **Fourth keyboard** . . . Solo group.
- **Pedal board** . . . Pedal group.

Added to these, of course, are percussion effects, such as bass drums, side drums each with tap and roll, Zylophone, Glockenspiel, Harp, Carillon, etc.

It may be of interest to mention that all the above are embodied in our Town Hall organ, Melbourne.
The talkie film, has, to a large extent, cut out the need for "noises-off" effects, but many cinema organs are equipped with such things as—

<table>
<thead>
<tr>
<th>Motor Horn</th>
<th>Sand Block</th>
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<tbody>
<tr>
<td>Fire Gong</td>
<td>Thunderstorm</td>
</tr>
<tr>
<td>Bird Whistle</td>
<td>Sea Surf</td>
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<tr>
<td>Sleigh Bells</td>
<td>Crockery Smash</td>
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</table>

The console being purely electric is only connected to the organ by a cable, and this enables the console to be moved about or elevated by a hydraulic ram, and turned if required.

The cinema organ is generally hidden behind grilles, and electric action allows of it being tucked away in sections in odd corners not useful for seating accommodation.

The same principles and quality of manufacture are, however, found in both "straight" and "extension" organs.

**Electrically-produced Tone.**

If a short bristle is attached to the end of a vibrating tuning fork, a smoked glass passed across its path will bear a line of a simple wave form. Similarly, but with more elaborate apparatus, such as the oscillograph, the particular wave formation of a violin, harp, piano, organ pipe, or human voice can be determined. These can be accurately analysed into the numerous simple sine wave formations which produce that particular kind of tone.

It is not surprising, therefore, that with the advent of broadcasting and talkies men's minds should turn to the subject of the production of organ tone by other means than that of the vibrations of columns of air in costly pipework.

One could imagine, for instance, an organ made by a series of 4-inch records with six sets of circular grooves, each set recorded from an actual organ pipe, the six pick-ups collecting the tone. Ten such records could be placed on a vertical revolving spindle and suitably spaced to provide room for the pick-ups. Each "stop" could be arranged on its own spindle, and the whole series driven through small bevel gears by a small motor. To minimise wear on the records, each record could run in its own oil bath and pick-ups be balanced, each stop in its own metal partition.

The overcoming of the joint problem in the vibration groove seems to be the only real snag in the scheme. It would be possible by this means to build a large organ in the space occupied by an ordinary piano.
Another scheme might be the taking of tone from talkie film strip, and producing it through a loud speaker as in cinemas. Sixty-one strips, each joined in a ring and made into a cylinder, would form a "stop." Each of these records could be taken from an actual organ. Thus the tone would be correct. These cylinders could all be driven at the correct speed by means of a small motor and gearing.

In both organs arrangements could be made for a slight variation of speed, making it possible to tune it correctly with a piano or singers who found it difficult to reach high or low notes easily.

Another idea was that of vibrations taken from a revolving toothed wheel against which a light metal or celluloid spring was held. A certain number of vibrations per second will produce a certain note, and a series of 61 discs with correctly related numbers of teeth mounted on a shaft driven at a certain speed would give correct notes for a keyboard. These vibrations could be picked up by electrical means when contact is made by depressing a key—"There you are"—but, as usual, there are dozens of snags, such as the quality of tone produced, the interference of one note with its neighbours, etc.

A well-known electric organ is based on this principle, but is cleverly worked out. The teeth of the discs are of special design. Instead of the spring being in contact, a tiny armature is substituted. When contact is made at the key, the current induced in the windings of the armature is taken through the valve amplifier to the loud speaker, where it produces a so-called fundamental note. By suitably combining vibrations from other fundamental notes in correct relative volume, it should theoretically be possible to produce any quality of tone. Some day this objective may be attained, but at the present stage this desideratum has not been reached. Most competent authorities are of the opinion that the trained human ear can detect the lack of many harmonics not at present provided in this type of organ, mainly because of cost. The longer one listens to a recital on one of these instruments, and to the alleged different qualities of tone, the more one realises that they are all the same.

Probably some day this type of organ will be able to compete successfully as to quality of tone plus price with pipe organs, but one need only listen to a recital on one of these for a short time to realise that this day has not yet arrived. The pedal department is certainly good, but one of the drawbacks in the writer's opinion is the too sudden beginning and ending of sound which is not restful to the ear. The quick crescendo and
the similar diminuendo of the tone from an organ pipe when the key is depressed and released is one of the restful characteristic charms of pipe organs. There are distinct possibilities, however, of producing new varieties of tone from these instruments, but up to the present we can only obtain pipe tone from a pipe.

Another type of pipe-less electric organ is one from which tone is produced by reeds vibrating under air pressure as in the ordinary "cabinet" organ. The direct sound, however, is not used, and the reeds are, therefore, in a sound-proof box. A tone screw head is placed in close proximity to the vibrating reed, and this screw is connected to the grid of a wireless valve and onwards to a loud speaker.

The quality of tone is, of course, determined by that produced by the reeds themselves, the chief advantage being that of power.

The pitch, power, and tone quality of the resulting reed tone depend on the length, thickness, and scale of the tongue. The length of the tongue is practically constant for any given pitch, varying from about 3\(\frac{1}{2}\) inches to less than \(\frac{1}{2}\) inch, and in width from \(\frac{4}{16}\) inch down to \(\frac{1}{16}\) inch.

The scale (width in proportion to length) varies considerably according to characteristic tones. A wide scale gives a full, round tone, and a narrow scale a more brilliant strident tone.

In conclusion I would like to thank the officers of the Australian Church, and my friend, Mr. Raymond Fehmel, for kind permission to use their fine Melbourne-built organ, which enables me to give you an idea of what an organ is like, what it can do in the way of tone production, and a slight idea of the way in which the organist is helped by the organ builder to control a large organ with ease.

I must specially thank Mr. Brodie, the manager of Messrs. Hill, Norman, and Beard, for his great assistance and kindness in placing at my disposal much more information than I could possibly have used, including free access to their workshop, which we hope to visit to-morrow, at Clifton Hill.

**VISIT TO ORGAN BUILDERS.**

On 13th July a visit was paid to the works of Messrs. Hill, Norman, and Beard Ltd., Clifton Hill, where members were shown in detail every branch of modern organ construction. The visit proved of exceptional interest, and the thanks of the Institute were conveyed to Mr. Brodie, manager, of Messrs. Hill, Norman, and Beard Ltd., for the very warm welcome and courtesy shown.
INDEX TO PLATE.

1. Portion of one type of multiple electric contact mechanism for 2 stops.
2. Original Hope-Jones stop switches.
3. A modern type of stop switch.
4. Elevation and plan showing stop knob electric contact.
5. Tubular pneumatic-action pressure system.
6. Slider type soundboard.
7. Electro-pneumatic slider operation.
8. Unison only coupling system for one note only of 3-manual organ on pressure system.
9. Dr. Albert Peschard's electro-pneumatic system. Patented 1864. This was noisy.
10. A modern electro-pneumatic system.
11. Unit electro-pneumatic wind chest as used for pedal stops, etc.
12. Direct electric action unit wind chest.
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16. Ordinary open wood pipe.
17. Sixteen feet open wood pipe showing tuning slide.
18. Hohl flute. Note that mouth is on wide side of pipe, and is bevelled on inside of pipe.
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20. Harmonic Flute invented by Cavaillé-Coll. It is twice the length of an ordinary pipe of the same pitch. Note the small hole halfway up the pipe.
21. "Dolcan" or "Dolce" pipe is an inverted cone.
22. Conical type, such as Spitzflote, Gemsborn, etc.
23. Pipes of a 3 rank "Mixture" to same scale as 15.
24. Old-fashioned tuning stool for open metal pipes. Nowadays a sliding sleeve is fitted to each pipe, by means of which the pipe can be lengthened or shortened, thus tuning it.
25. & 25A. Boot of reed pipe.
27. Trumpet.
28. Top of "Cor Anglais."
29. Mitred and crooked "Trumpet," to reduce length of large pipe when space is limited.
30. Oboe.
31. Orchestral Oboe.
32. Special Trumpet in Temple Church, London.
33. Vox Humana (note short resonator).
34. Thirty-two feet Contra Bombarde, with wooden boot and pneumatic starter for prompt speech.
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