much in favour of the atmosphere and psychological characteristics which derive from natural lighting of these rooms. Each theatre has its own projection room equipped for dual projection. This arrangement is essential when making comparisons or illustrating a building with its plan. Standard Liesegang and 35 mm. Leica projectors with long-throw lenses provide for the various slides and book illustrations. The largest theatre has a Filomsound 16 mm. cine projector, wired to dual speakers, while a Bell and Howell silent projector is available for the smaller rooms.

In order that students may take notes during illustrated lectures, a system of louvred recessed ceiling lights was adopted. These avoid undue spread of light and consequent glare and sight of the light source which is so discomforting to an audience. They are arranged on a dimming circuit so that the intensity may be adjusted to provide sufficient illumination in the room without affecting the clarity of the projected picture. Electrically operated sliding steel shutters rapidly provide the necessary black-out and when these are closed the plant providing forced ventilation (and heating) is switched on. All these operations are controlled by the lecturer at the lectern, which in addition has an intercom connected to the projection room. Consequently in a matter of seconds the theatre may be adjusted to the demands of the various lecturing programmes.

The theatres are equipped with "Nucite" tempered glass chalk boards sprayed with enamel containing aluminium oxide abrasive, which are claimed never to wear smooth, warp or fade.

The layout of the studios, with drawing tables at modular intervals, includes in each case the partitioned recess used for informal discussions, programme briefing and display of pertinent information. Lighting is by continuous fluorescent fittings disposed to give even shadowless lighting over the whole area. Sun control on the north is provided by neutral tinted glass in aluminium frames. These both even out the light intensities from both sides of the room and avoid the objectionable "blinker" effect of solid louvres.

Supplementing the briefing spaces in the studios is the Crit Room, having fluorescent lighting and absorbent ceiling panel, where formal design criticisms take place. One difficulty encountered early in the design stage was the absence of a suitable reasonably priced material which could be used to pin up drawings. The author induced the ultimate supplier to experiment with a reduced glue content in a loosely compressed chip board. The result was an attractive panel faced with a soft veneer, used for all pinning surfaces and now marketed under the name "Raydecor."

Some mention of the lock and master key system of the building appeared in an earlier article*. The Departments of Architecture and Quantity Surveying, of Fine Arts and the Library, required careful co-ordination of their demands, since each enjoys its own special accommodation but shares certain common facilities. In addition to grandmasters each is separately masterkeyed, while the key to each staff office is also the pass key for departmental facilities, thus avoiding cumbersome bunches. The inconvenience of having to open a locked door while carrying lecture material or a brief case led to the use of the key-in-the-knob "Schlage" equipment. Some 150 "Novo" locksets, many with "Riviera" escutcheons were used. Special "Assa" swing-door lockets were used on the theatre and library doors.

Testing and experimental laboratories as such do not form part of the complex since these facilities are available in the engineering departments on the Campus.

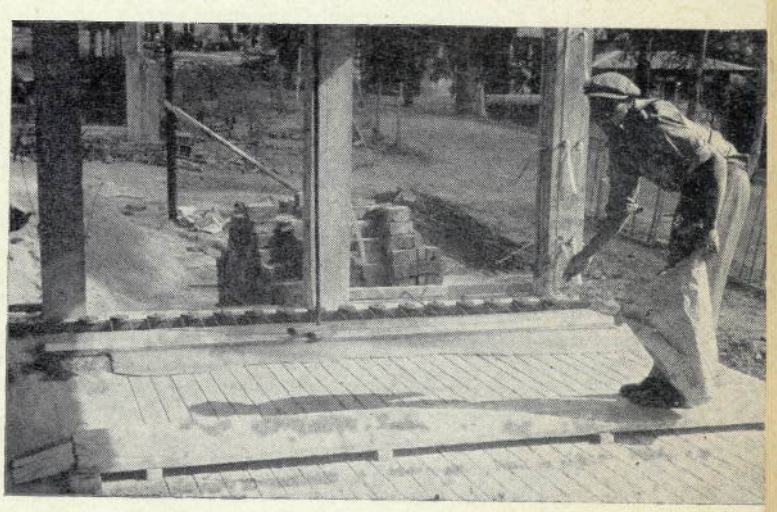
TECHNICAL FEATURES

Most important of these was the introduction of electrical floor heating throughout the building, including corridors. The architects' approach to this problem was strengthened when the author received instructions to use electrical heating and avoid the installation of coal-fired boilers with all that these entail.

Various forms of electrical heating from convectors to radiant panels were considered. By reason of the furnishings no form of heating unit beneath the window cills could be contemplated, neither on the score of efficient operation, since in some cases students would be within two feet of the surfaces, others fifteen feet away, and the fact that the units would be masked by desks, nor on the score of accidental damage and tampering. High level units were not considered suitable as these would not warm the

"A Comprhensive Door and Door Furniture Shcedule." *S.A. Architectural Record, Vol. 44: No. 5.*

The building is warmed by electrically heated cables in the floor. The cables are shown led round adjustable rollers on a steel channel member which straightens the cables when the bolts to the column struts are taken up. Wires are pressed down onto the slab surface and the first $\frac{3}{4}$ in. thickness of screed applied, as the illustration indicates. When set the roller units are removed and screeding completed. Subsequently the final screeding making up a finished thickness of $1\frac{1}{2}$ in. is applied. Some 1,000 feet of cable make up each circuit.



areas near the floor, and cold feet are not conducive to comfort or concentration.

It was thus decided that heating built into the floor was the most suitable solution to the problem, giving complete flexibility of furniture arrangement and freedom from interference or damage and having a centralised control. A further advantage of the system was the flexibility of application, since for periods of the year studios would not require heating but the administrative and staff offices and the library would. Consequently sections of the building can be switched out and when staff rooms require heating in such sections they use the independent built-in "Tempadair" convectors.

These were the design problems passed to the Electrical Consultants. At the time the designs were prepared little information on electrical floor heating could be found to give a reliable solution to the various problems and a considerable amount of research was entailed.

Effect of Floor Heating

The Structural Engineering Consultant was concerned at the possible damage accruing should the installation overheat, and, since the floor was built up of prestressed beams with hollow tile infilling, there was some point to his anxiety. The architects too were concerned at the possibility of hair cracking developing on the plastered ceiling surfaces. The National Building Research Institute had carried out observations on concrete slabs exposed to the sun, and from this information it was decided that the temperature of the floor heating cables should be limited to 150° C.

The Electrical Consultants gave the assurance that such temperatures could be calculated and advised that the floor temperatures would not get out of control nor the cables overheat. On the final installation it was found that temperatures were as calculated while providing excellent comfort conditions in the building and not causing ceiling cracks.

Effect of Floor Heating on Floor Coverings

Temperature calculations indicated that floor finishes would not be affected. That used was $\frac{1}{8}$ in. cork linoleum laid with adhesive. No excessive temperatures were measured even when a carpet and underfelt were on the floor or the surface covered by solid furniture.

Liability to Damage

Although precautions were taken in the pre-location of floor spring hinges, spring door stops and other floor fixings it was realised that the cables could be damaged by bolts, etc., let into the finished floor. The Electrical Consultants were satisfied that such breaks could be rectified and in fact several cables were damaged by sub-contractors and were successfully repaired.

Thickness of Floor Finish

The Electrical Consultants advised a minimum cover of screed plus finish of $1\frac{1}{4}$ in. over the cables, and in some cases only $1\frac{3}{8}$ in. was obtainable.

General Arrangement

The system was the non-withdrawable type in which the floor heating cables were laid directly on the concrete floor slab and covered with plaster screed. The cables were taken to terminal boxes built in to the outside walls at skirting level at intervals of approximately 15 feet. The terminal boxes were connected to distribution boards by means of rubber insulated wire in conduits cast into the concrete slab. At the distribution boards miniature circuit breakers were used. The boards were in turn connected by means of paper insulated cables to the transformer supplying the heating system, located in the basement substation.

Construction Problems

The problem of laying out approximately 1,000 feet of cable from a coil in parallel lines across the building at a pitch of some 5 inches so that the two ends relate accurately to the terminal box was encountered. To do this by hand with a minimum of flexing of the cable, even with the aid of chalk marks locating the spacing of the lines was tedious and unworkmanlike. The cable once laid had to be located and temporarily held down by placing bricks on the lines at intervals. On reaching the end of the circuit the adjustment of the complete length of cable throughout its run of some 36 parallel lines in order to bring the free end in accurate relationship with the terminal box was even more tedious. Moreover in order to avoid displacement of the lines once laid and damage during construction it was necessary to cover the cables with about $\frac{3}{4}$ in. of plaster screed immediately after laying, no easy task on the loosely laid cable. This meant of course that a section of the floor had to be cleared to permit the laying of the cable and that plasterers had to follow up with the screed immediately.

The author finally evolved the method whereby a series of rollers of diameter equal to the particular pitch involved and spaced at corresponding intervals along lengths of steel channel units located on opposite sides of the floor section. The cable was then led off the drum mounted on a cradle and round the rollers, which thus established the parallel lines and facilitated the adjustment of the free end in relation to the terminal boxes. The channel units were then drawn towards the outside edges of the adjustment of the free end in relation to the terminal box. the floor section by means of bolts strutted off the concrete column, thus pulling the cables tight and straight between opposite rollers. Cables were then pushed down on to the concrete surface by 9 in. × $1\frac{1}{2}$ in. planks propped off the slab above so that the former lay flat on the concrete and at the bottom of the screed. The plasterers then screeded the central section and when this was set the channel unit rollers were removed, the loops of cable bedded down and the screeding completed.

It was found in practice that the work went very smoothly once the first circuit had been done and the method fully understood by the electricians, plasterers and the building contractor.

Cost

The following are the final costs of the floor heating installation:

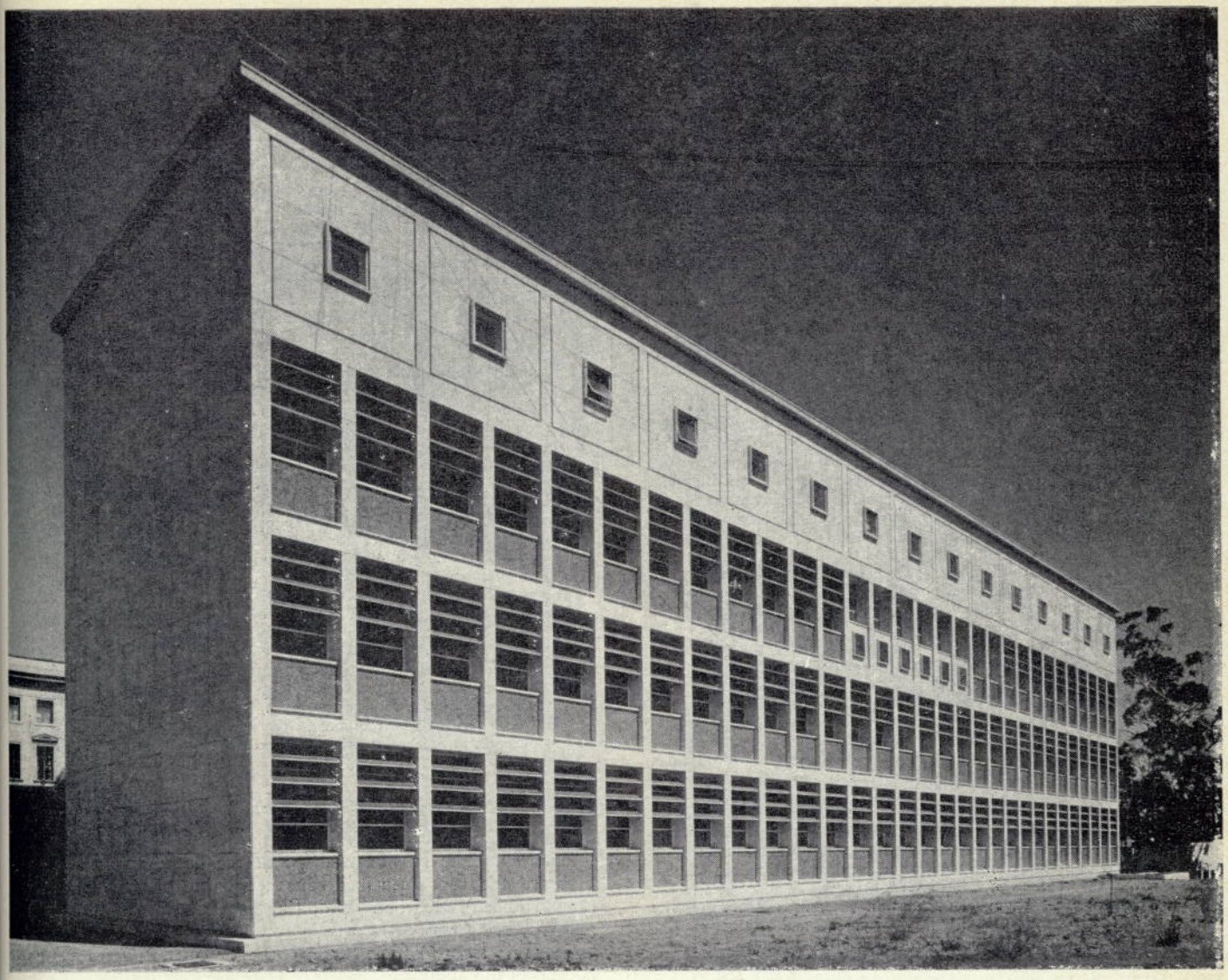
		s.	d.
A.	Installation costs per square foot of heated floor area		
	Floor heating cable installed, including terminal boxes and connections	2	3
	Share of power supply, including switchboards, cables and transformer	3	0
	TOTAL	5	3
B.	Running costs of floor heating installation:		
	Costs of electricity consumed for one 30-day month based on present Johannesburg electricity tariff, which was recently increased (per square foot of area)	1·35d.	

The foregoing costs may be compared with those which have been obtained for equivalent electric heating installations (it should be noted that the floor heating installation was designed to match in cost and performance an equivalent installation of convector type heaters).

Initial Cost for Convectors

Ordinary convector heaters installed complete (Cost per square foor of room heated):

	s.	d.
Convector plus connection to distribution board	1	9
Share of power supply equipment, including swtich-boards, mains and main power transformer	3	6
TOTAL	5	3



Photography by J. G. Boss.

The North elevation of the studio wing. The Art studios, with small north windows occupy the top floor. A visual accent is provided in the centre of the facade by the six red mosaic panels, the remainder having blue glass mosaic spandrils as elsewhere. The deep recesses of the openings accommodate and provide hail protection to the aluminium framed neutral tint glass louvres, six of which were temporarily missing when the photograph was taken.

Running Costs of Convectors

Cost for one 30-day month based on present Johannesburg tariff and on 200 running hours per month.

Electricity per square foot of room floor area	*From:* 1·4d. to 2·3d.★

A paper published in 1958 gives the following installed costs for floor heating equipment in the United Kingdom. Unfortunately it is not made clear whether the costs are inclusive of the power supply equipment but it is thought that they were not inclusive:

Directly embedded system	2s. 9d. to 3s. 6d. per sq. ft.
Withdrawable system	7s. 0d. to 8s. 6d. per sq. ft.

Operating Experience

It was found that floor heating system produced very comfortable conditions as the rooms and corridors were uniformly warm and there was no sensation of temperature gradient from floor level to upper level. There was also an absence of cold draughts across the floor. The sensation of warmth at the feet was pleasant and the floor was pleasantly warm. Apart from the supplementary heating in the staff offices, fan heaters were installed in the Art studios for the benefit of nude models to ensure that it would be possible to maintain the studio air at comfort temperatures at all times. Owing to the large window area of these rooms there was a considerable area of infiltration and it was necessary to ensure that the air be kept warm.

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The architects acknowledge the helpful services of W. J. Carter, B. S. L. Gloag and L. Gruzd in the preparation of drawings and pay tribute to the sustained enthusiasm of Mr. Gruzd whose intimate knowledge of the scheme and ubiquitous presence was valuable during building; also to the contractor and sub-contractors and in particular to Mr. A. Sutherland, the general foreman.

W. D. H.

★ Depending on occupancy of rooms and consigned utilization of heating.