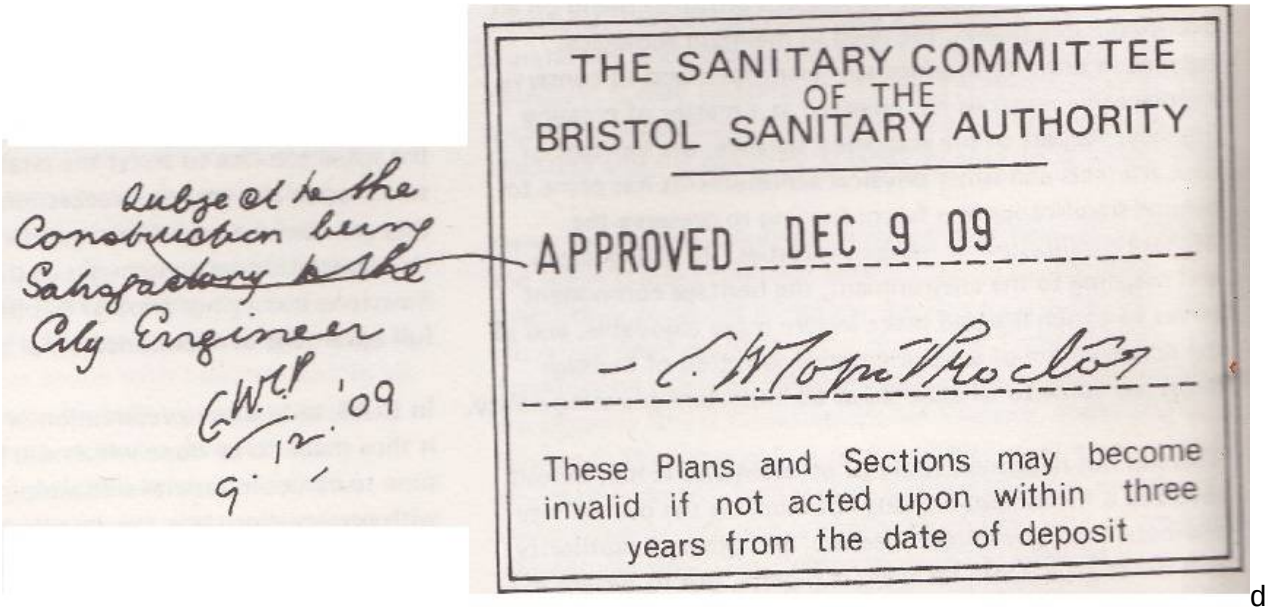
THE WCA WAREHOUSE

David Cocks

The Western Counties Agricultural Co-operative Association Ltd are first recorded as occupying premises in Redcliff Backs in 1898 (1). Trade evidentally flourished and, at the end of their first decade, WCA commissioned W H Brown MSA AMSE of Standard Buildings, Leeds and 36 & 38 Victoria Street, Westminster, to design a new reinforced concrete framed Warehouse to be constructed immediately adjacent to the Floating Harbour and the, now disused, Redcliffe Ferry.
Towards the end of 1909 the design had been completed and, on the 28th October, they submitted their formal Notice to the Sanitary Committee of the Bristol Sanitary Authority of their intention:-
to erect a New Warehouse, situate and being on Redcliff Wharf on the Floating Harbour in the Parish of Redcliffe St.Mary.
The materials of which the building proposed to be constructed are:-
Reinforced concrete in Perfector system as follows: Foundations, concrete piles 14" x 14", reinforced concrete columns and floors. The columns will be clothed on outside with reinforced brickwork and panels between columns filled in with 11" cavity reinforced brick wall."
The Notice was substantiated by certain drawings but it appears that the Sanitary Authority may not have been entirely satisfied with the amount of detailed information available as, six weeks later, WCA sent the following letter to the Building Inspector:-

"Dear Sir 7th December 1909
Proposed New Warehouse, Redcliff Wharf
In connection with the above we beg to make the following applications and trust that they will be given yours and your Committee's fullest consideration.
1) To clothe the reinforced concrete structure with, reinforced brick and cement cavity walls, as described on the floor plans and in the enclosed book.
2) To erect projecting penthouses on the street side; commencing from the second floor to be formed in reinforced concrete, and supported from each floor by reinforced cantilever beams.
3) Also to form 3 hauling slopes in footpath where shown on plan. It may be pointed that such slopes exist to the old building.
The concrete columns, beams and floors will be formed and reinforced as shown on the illustrations, the concrete being composed of granite sand and cement.
At present there is no intention of making any soil drain, the water from the asphalted roof being carried down to the floating harbour.
Yours faithfully
per pro
The Western Counties Agricultural Co-operative Association Ltd.
Harold N Alver Clerk of Works

Only two days later, on 9th December 1909, the application received the formal approval of the Authority. The stamp of approval, reproduced in Fig.1, stated that "These Plans and Sections may become invalid if not acted upon within 3 years from the date of deposit" and was "Subject to the construction being satisfactory to the City Engineer". The existing building bears such close resemblance to the original



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wings deposited with the Authority that, in the absence of a subsequent application or other records, it is reasonable to assume that construction was commenced within the specified time limit and that the Warehouse dates from approximately 1910-1913.

The original Notice and letter to the Authority, together with several highly detailed drawings in the style of the
day and a small number of documents of minor importance, are still retained by the City Engineer and Planning
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Department. Unfortunately the book referred to in the letter to the Building Inspector has been lost and it is also no longer possible to establish details of the 'Perfector' system. A simplified plan and cross section, based on the original drawings, is shown in Fig 2. There are various discrepancies between the existing building and the original drawings but these will be described later. It is interesting to note the variations in spelling of Redcliff Backs, Redcliff Wharf, Redcliffe St.Mary, Redcliffe Way and Redcliffe Ferry which still exist today.

The Design of the Warehouse

The Warehouse consists of a four storey open plan reinforced concrete framed structure, clad externally with high quality red brickwork, with a penthouse, constructed in loadbearing brickwork, located on the central area of the main roof. The principal dimensions are approximately 105 ft. length (parallel to the Floating Harbour), 71 ft. width and 60 ft. overall height. Initial appearances are misleading, due to inevitable weathering, but the Warehouse is worthy of much closer attention.

The east elevation to Redcliff Backs and the west elevation to the Floating Harbour are both extremely well detailed with the column and floor positions being expressed by vertical full height projections in the brickwork cladding and horizontal bands of cement: sand render respectively. In addition, there are three very interesting cantilevered goods hoists on each of these two principal elevations.

They generally commence at second floor level and extend almost as high as the upper roof level. However, on the east, the central one commences at main roof level and terminates at upper roof level and, on the west, the central one commences at second floor level and terminates at main roof level. The cantilever hoists are constructed in reinforced concrete, as originally described by Harold N Alver, and finished externally with cement: sand render. The render is generally in good condition although it is now extensively weather-stained and has even fallen away in isolated places, thus exposing the concrete behind. The east and west elevations are both balanced aesthetically by a

large number of finely proportioned windows. The north elevation, to the now disused Redcliffe Ferry is very similar in character to the principal elevations but without the cantilevered goods hoists. The most commonly seen south elevation, facing the Parish Church of St. Mary Redcliffe and the nearby Bascule Bridge in Redcliffe Way (which superseded the Redcliffe Ferry), is relatively disappointing as it lacks the fine detail of the other three elevations. In addition, there is evidence that the Warehouse was at one stage attached to an adjacent two storey building as the brickwork on the south east corner has been roughly broken, the first two stories of the wall have been whitewashed and a fire escape ladder from the roof terminates at second floor level. This is apparently confirmed by the drawings originally deposited with the Sanitary Authority which indicated the existence of an adjacent property called the Carpenter's Arms. The elevation is further defaced by a number of fire doors and other
openings which have been provided in the past. However, this elevation is significant as the reinforced concrete frame is exposed and thus provides the only external indication of the true nature of the structure.

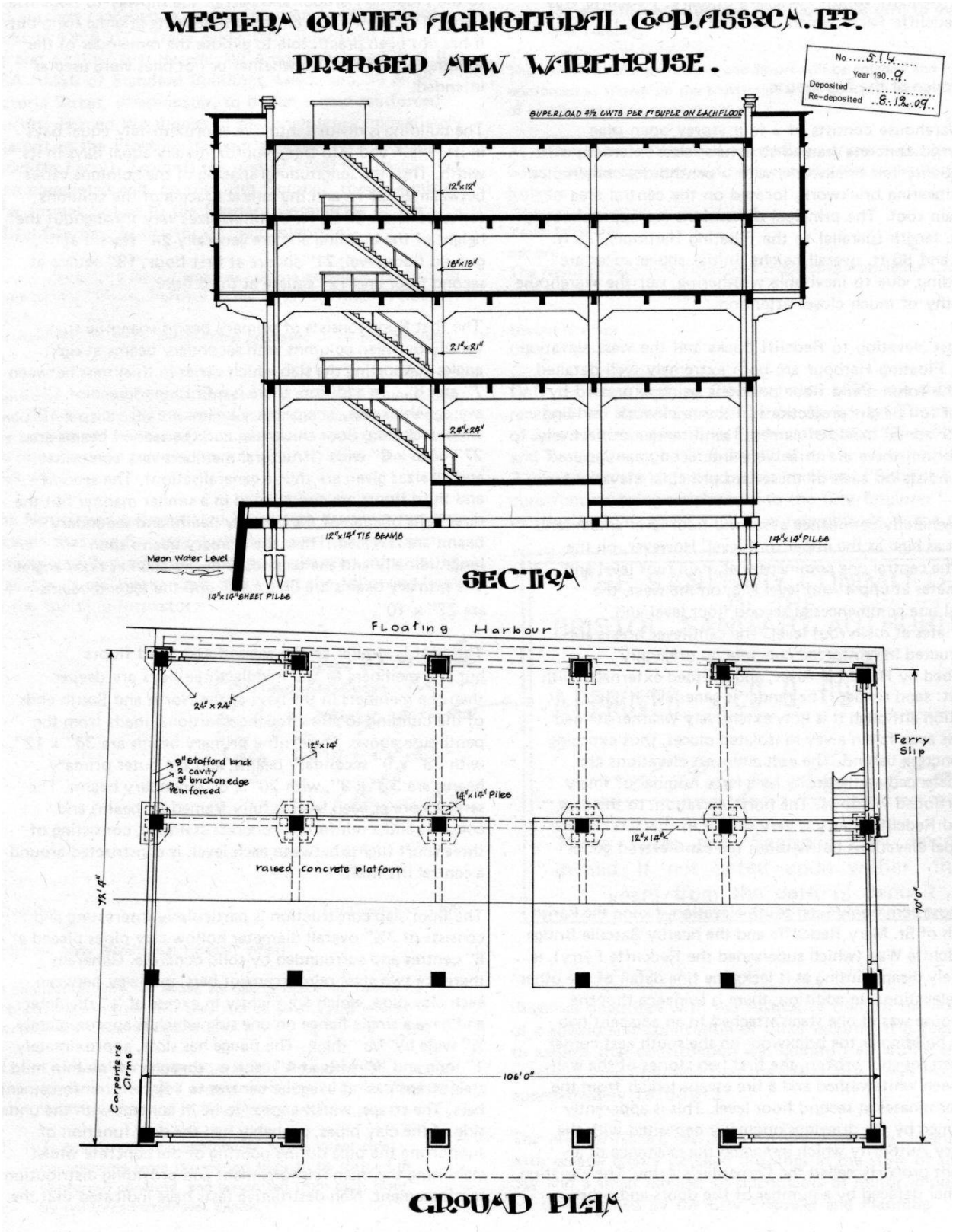
The drawings originally deposited with the Sanitary Authority indicate that the foundations consist of 14" square precast concrete piles which were also used to form the Quay Wall to the Floating Harbour and part of the slipway to Redcliffe Ferry. The quay is still clearly visible in its original form but it has not been practicable to expose the remainder of the foundations to confirm whether or not piles were used as intended.

The building is divided into five approximately equal bays in its length and into three approximately equal bays in its width. Thus the longitudinal spacing of the columns varies between 20-21 ft. and the lateral spacing of the columns varies between 23-25 ft. Columns sizes vary throughout the height of the building and are generally 24" square at ground floor level, 21" square at first floor, 18" square at second floor and 12" square at third floor.

The first floor consists of primary beams spanning transversely between columns with secondary beams at right angles supporting the slab which varies in thickness between 7" and 8". In addition, there is a finishing screed of 1" average thickness. The primary beams are 38" deep x 12" wide, including floor thickness, and the second beams are 27" deep x 8" wide (structural members vary somewhat and all sizes given are thus a generalisation). The second and third floors are constructed in a similar manner but the directions of span of the primary beams and secondary beams are reversed. Thus, the primary beams span longitudinally and the secondary beams span at right angles. The primary beams are 36" x 12" and the second beams are 27" x 10".

The roof is similar to the second and third floors but the members in the middle three bays are deeper than the members in the bays at the North and South ends of the building to allow for the additional loads from the penthouse above. The central primary beams are 36" x 12", with 28" x 9" secondary beams, and the outer primary beams are 32" x 9", with 20" x 6" secondary beams. The service core at each level is fully framed by beams and columns and a reinforced concrete staircase, consisting of three short flights between each level, is constructed around a central lift shaft.

The floor slab construction is particularly interesting and consists of 3'/2" overall diameter hollow clay pipes placed at 8" centres and surrounded by solid concrete. Generally, there are two steel reinforcement bars, mid-way between each clay pipe, which are slightly in excess of '/z" diameter and have a single flange on one side which is approximately '/z" wide by 1/8" thick. The flange has slots, approximately 1" long and '/4" wide at 4" centres, through which thin mild steel straps pass at irregular centres to adjacent reinforcement bars. The straps, which appear to be in contact with the underside of the clay pipes, probably had the dual function of supporting the pipe during pouring of the concrete whilst stabilising the main reinforcement and providing distribution reinforcement. Non-destructive tests have indicated that the



concrete strength varies from 5000 to 8000 lbf/in2 but that the average is generally of the order of

6000 lbf/in2.
The gable brickwork at ground floor level consists of a 9" thick outer leaf, 2" cavity and 3" thick reinforced inner leaf built with brick on edge. The reinforcement consists of a three inch wide expanded metal strip set into the horizontal joints of the brickwork. The gable brickwork at the upper levels is similar to that at ground floor but with a 4'/z" thick outer skin. The facade brickwork is a mixture of 9" thick solid and cavity brickwork with a 3" thick reinforced inner leaf.
Condition of the building
The structure is generally in good condition although a number of hairline cracks occur mainly in the floor slabs and also, in isolated cases, in the beams themselves. Somewhat larger cracks occur at the second and third floor levels in the extreme South West bay in both the floor slabs and the supporting beams although the worst case is undoubtedly at third floor level. The floor slab at the second floor level immediately adjacent to the grain hoists on the east elevation and the middle grain hoist on the west elevation is cracked and this crack is also evident in the non structural screed.
The roof slab is in a worse condition than any other part of the structure as the reinforcement is frequently exposed and corroded. This has resulted in widespread spalling of the concrete on the underside of the roof slab resulting locally in ingress of rainwater. The penthouse structure has also unfortunately been severely damaged by vandals.
The original drawings deposited with the Sanitary Authority state that the Warehouse was designed for a superimposed floor loading of 41/2 cwts/ft2 (504 lbf/ft2). An equivalent modern building for the storage of grain, for example, could be required to be designed for a superimposed loading of up to double this figure. It is therefore possible that overloading has occured in the past and the cracks that occur in the south west bay at the second and third floor levels are compatible with the excessive deflections which would be expected under these conditions. However, there is also the possibility of a general settlement of the south west corner of the building to consider although the remainder of the structure shows very little evidence to support this.
A fire has occurred in the past in the northernmost bay of the ground floor as the ceiling is covered with a layer of soot and there is fire damage to window frames etc. Extensive hairline cracking exists in the underside of the slab and beams at first floor level and spalling has occurred locally. Unfortunately, the Local Fire Authority have no records regarding the Warehouse and, in the absence of information regarding the duration and intensity of the fire, it is impossible to establish how significant the damage is without subjecting the area to a load test.
Modifications have been made to the structure during the life of the Warehouse although these have generally been confined to cutting holes in the floor slabs and walls for the provision of grain chutes. Varying degrees of care
have been exercised as, in some cases, these have been cut oversized and trimmed neatly with new concrete to the size required, whereas, others have cut roughly leaving the floor reinforcement exposed at the edges.
A number of discrepancies between the drawings originally deposited with the Sanitary Authority and the Warehouse as constructed are apparent. These include the omission of the penthouse structure at roof level and the associated variations in construction of the main roof to allow for the difference in loadings, the omission of the central core area, the inclusion of a staircase in the North West corner of the building, the omission of raised concrete platforms in the centre of the ground floor,
the direction of span of the primary and secondary beams at various floor levels and the number of secondary beams at first floor level. Although these variations would be significant by today's standards and normally a further submission of details would be required, it is likely that changes were found desirable as the design was finalised and that the Authority was quite prepared to entrust the design and detailing to the care of W H Brown.
Constructional techniques

To appreciate the chronological significance of the WCA Warehouse, designed in 1909 and thought to have been constructed circa 1912, it is necessary to consider the development of reinforced concrete as a structural medium. As early as the third century BC (2), the Romans had started to use a form of concrete consisting of firmly compressed alternate layers of brick or stone rubble and a mortar of which the most important ingredient was pozzolana. At first it was used for walls and foundations but it eventually permitted the construction of vaults and domes of a magnitude unequalled until the introduction of steel in the 19th century. The limiting factor was that structural forces had to remain compressive, due to the poor tensile properties of the concrete, and it was generally necessary to provide massive buttresses to resist the thrusts.

The Romans discovered that, although increased structural thickness of vaults and domes tended to limit deflection, it was not necessary to maintain the same depth throughout for loadbearing purposes and they, therefore, developed a system of eliminating unnecessary weight by either introducing coffers on the underside or constructing alternative ribs of concrete and brick. The highest expression of the Roman's genius as architects and builders is generally taken to be the Pantheon in Rome, built by the Emperor Hadrian in AD 120-125 (3). The hemispherical domed roof of the Rotunda has a diameter of 142'-6", which is equal to the height of the crown above ground level, and varies'in thickness from 19"-4" at the base to 4'-11".

The beginnings of the modern development can be traced back to the last half of the 18th Century when cast iron

first began to be used for utilitarian structures such as bridges. By 1800, the professions of Architect and Engineer had already become separate with Architects training in Schools of Architecture or established offices and Engineers in France at least, in Technical Universities. Nineteenth century Engineers made extensive use of cast iron and, after circa 1860, steel. The most perfect examples of early iron structures are the suspension bridges such as Brunet's Clifton Bridge in Bristol, designed in 1829-31 although not completed until 1864.

America established priority in the development of structural steelwork and one of the first completely steel framed buildings was the Home Insurance Company Office in Chicago, designed by William Le Baron Jenny and constructed in 1884-5 (4). However, the first buildings to achieve complete independence from the past, by expressing the structural frame externally, were designed by Louis Sullivan and included the Wainright Building in St.Louis (1890), the Guaranty Building in Buffalo (1895) and the Carson Pirrie and Scott Store in Chicago (1899). The first significant building of this nature in this country was reputed to be the Ritz Hotel in London constructed in 1905-6(2).

French invention achieved a narrow lead over British, German and American and in 1892 Francois Hennebique produced and rapidly exploited a complete system of reinforced concrete; this being closely followed by many other proprietary systems. Auguste Perret began practice in Paris in 1895 and devoted himself to the advancement of the technique and art of reinforced concrete. He is particularly credited for his famous block of flats in the Rue Franklin (1902-3), the exposed concrete of the garage in Rue Ponthieu (1905) and his Theatre des Champs Elysees (1911-12) which was the first reinforced concrete framed public building in France.

During this period, reinforced concrete technology was developing rapidly and the Swiss Engineer Robert Maillart produced his first splendidly simple flat slab bridge design in 1906 and had developed it as a frame system for buildings by 1908. Eight years later, the impressive parabolic vaulted airship hanger, designed by Eugene Freysinnet, was constructed at Orly in 1916. The advanced techniques of Maillart and Freysinnet, however, did not come into general use until after the Great War; the normal early structural system being that of the box frame outlining the space to be enclosed. One of the earliest recorded uses in this country was in the construction of the world's first reinforced concrete water tower in 1900 (5) although the initial appearance of the material in a building of importance was reputed to have been in extensions to the General Post Office in London in 1907.

The unique technology of reinforced concrete presented a necessity for establishing regulations to control its use and in 1908 the Royal Institute of British Architects convened the "Joint Committee on Reinforced Concrete" who published their first report later that year and a second one three years later (6). In 1909, the LCC General Power Act made provision for the use of reinforced concrete and draft regulations were prepared in 1911 for approval by the Local Government Board; final regulations being issued in 1915. The first formal Code of Practice was issued nineteen years later, by the Department of Scientific and Industrial Research, in 1934 and was a forerunner to the Codes subsequently by the British Standards Institute (7), (8).

The WCA Warehouse was thus designed during a period when the new technology of reinforced concrete was developing rapidly and when attention was first being given to the drafting of adequate regulations and recommendations regarding its use. The Engineers of the day had to rely on basic principles and their own intuition, together with the groundwork established by their contempories, rather than on long established theories and Codes of Practice as is the case today.

Although the Warehouse is simple by comparison with the work of both Maillart and Freysinnet, it is nevertheless a fine example of the era by being a simple brick clad framed structure. The frame is expressed to a limited extent, in the principle elevations, by the full height projections in the brickwork cladding at column positions and by the horizontal bands of render at the floor levels. As such, it represents a step between tradition and pure expression of the structural form.

Finally, despite numerous advances in the development of reinforced concrete technology during the last 65 years, it is of particular credit to W H Brown that an Engineer today would provide an almost identical structural solution if given the same design parameters.

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ACKNOWLEDGEMENTS

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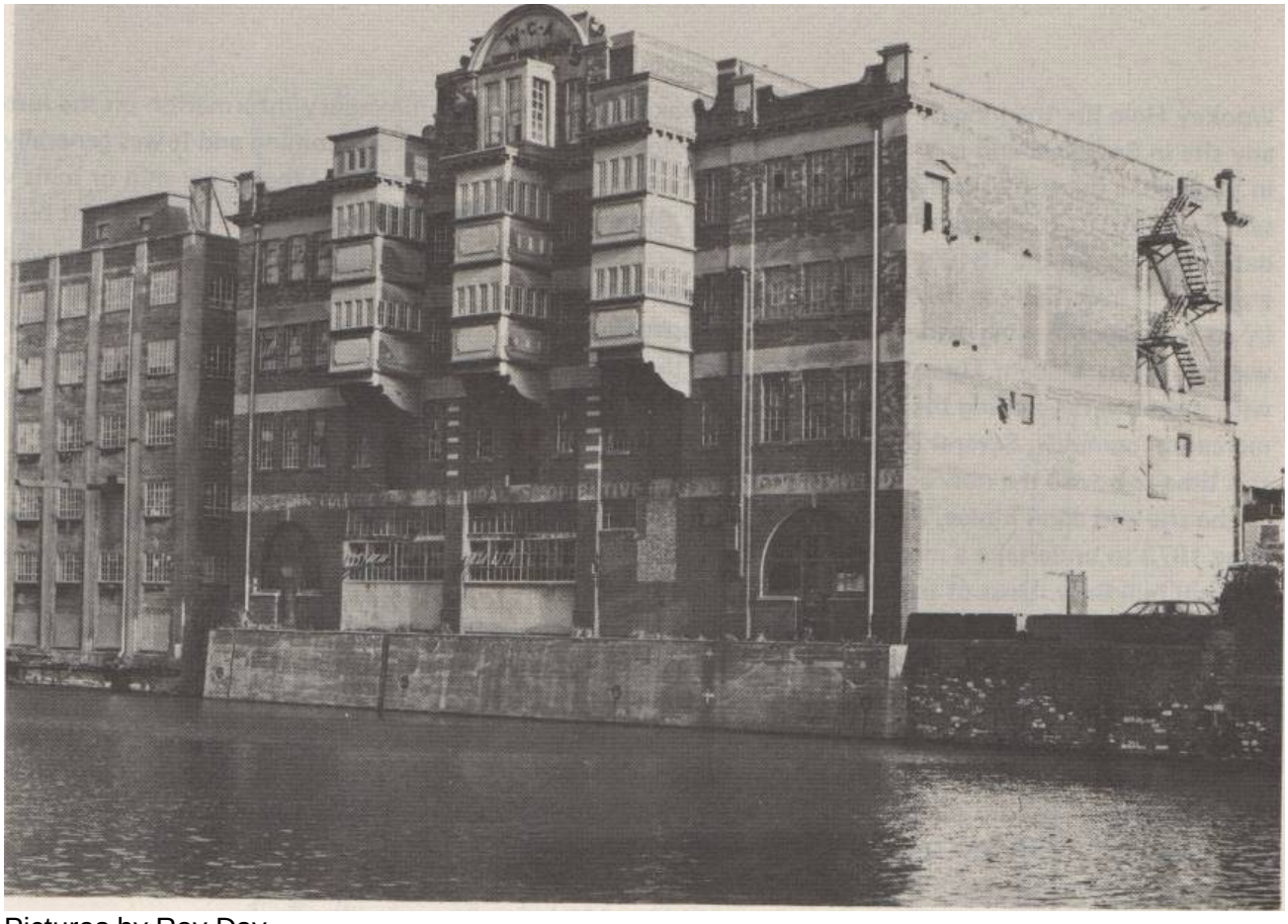

Pictures by Roy Day