a mile apart, while the third aerial runs on rails extending half a mile to the west of the centre aerial. Thus signals corresponding to two spacings can be recorded at the same time, and all spacings up to one mile are possible. As well as the saving in time, this layout means that the length of accurately placed rail to be laid is reduced by half. The three-mile instrument extends the concept further with eight aerials strung out over three miles. Four of the aerials—42 foot dishes—run on a three-quarter mile length of rail laid at the eastern extremity of the array to an accuracy better than one millimetre. The four similar fixed dishes are to be evenly spaced over the remainder of the three-mile system, and sixteen spacings will be available simultaneously. One twelve-hour run will be enough to plot a rough chart of the radio emission from an object, while eight runs will draw the complete map. But the complexity means that a computer is needed at the site—so far the punched tape output of the observatory's telescopes has been taken into Cambridge for processing at the university. The Myriad 2 computer which has been chosen will have a 30 inch line plotter to draw the maps, and will also control the eight telescopes.

When the three-mile telescope is built, the present one-mile instrument will be devoted largely to source counting. The view seems to be that most of the fainter sources have been seen, so that there is little point in looking back to even fainter sources. This is why it now seems more important to build an instrument for source mapping. The curious result is that the resolving powers of radio and optical telescopes are now rapidly converging.

ARCHAEOLOGY

Ludgershall Castle

from our Archaeology Correspondent

As the Ministry of Public Building and Works knows all too well, visitors who go out of their way to visit Ludgershall Castle in Wiltshire are apt to get annoyed when they discover that there is little to see above ground apart from the stump of a twelfth century tower. This is one reason why the ministry has financed a major excavation at the site, directed by Mr P. Addyman of the University of Southampton, during the past five seasons. There are, however, more academic justifications for the excavation. For one thing, from the beginning of the twelfth century until the fifteenth the castle was a royal residence and account books have survived, so there is an opportunity to correlate archaeological and documentary evidence. For another, Ludgershall in the twelfth century was a major ring-work castle, and only a few of them have been excavated. In fact the present day remains of the earthwork have an unusual figure of eight shape, which adds to the interest of the excavation.

The earliest reference to Ludgershall Manor is in the Domesday Book. In 1086, it was owned by the Earl of Salisbury, but by 1103 it was in the hands of Henry I and it remained a royal residence until the fifteenth century, evolving in that time from a castle to a hunting lodge. The excavations have revealed no fewer than fifteen phases of construction as the buildings were repeatedly pulled down, rebuilt and extended, and these promise to give a detailed picture both of building

Bone strip decorations from the lid of a twelfth century casket discovered at Ludgershall Castle. The three central strips may have been inlaid with silver. The casket had two iron hinges and two iron hasps.

techniques and of the way of life in a royal household.

The figure of eight ring works, consisting of a ditch, a bank and an inner ditch, were built in two phases. The first fortification on the site, what is now the southern ring of the figure of eight, was built in the mid-twelfth century, perhaps by John the Marshall, who had a reputation for building castles "wonderous of devise", during the civil war between Stephen and Matilda. The northern loop of the figure of eight was added by Henry III. Originally the ditches were some twenty feet deep with very steep outer faces, and the banks were made of chalk revetted with timber.

In the twelfth century there were only wooden buildings in the southern ring, which can be securely dated by a coin of Stephen. Curiously enough, a large number of fox bones have been found, some of which show deficiency diseases; this raises the interesting possibility that foxes were being farmed at this time, presumably for their pelts. In the thirteenth and fourteenth centuries the area was redeveloped as servants' quarters. The wooden buildings were replaced with timber framed, flint walled houses and the large number of cattle bones indicates that their occupants had a comparatively simple diet.

The northern loop of the castle, by contrast, was developed into palatial royal quarters. During successive reigns, stone buildings of increasing sophistication were built there, and the defensive features of the castle, including the ditches, were progressively sacrificed for increased luxury as the castle evolved into a hunting lodge.

The architecture was of a standard fit for a cathedral, with intricately carved pillars, painted plaster walls and large windows. The royal buildings include a great hall, a solar-hall and kitchen range, sleeping chambers and a stone lined latrine; building materials include Cornish slate, Purbeck marble, Bath stone and stone from the Isle of Wight. As the contents of the latrine have shown, royal tastes in food matched those in architecture; literally thousands of quail and small bird bones have been found, as well as oyster shells, lobster shells and the bones of deer.

Ludgershall is the richest mediaeval site excavated in Britain; more than 5,000 iron objects have been recovered as well as numerous pieces of jewellery, a gilt spur, bronze and bone artefacts (see the photograph) and pottery. If a small fraction of the finds was put on display in a museum on the site, the ministry would no longer suffer from the complaints of disappointed visitors. And when the embarrassing wealth of material has been examined and catalogued, it should give a unique picture of almost every aspect of the daily life of the period.

MANAGEMENT

Too Late and Too Dear

WHAT do Concorde, the QE2 and Dungeness B power station have in common? All three are late, and all three are going to cost more than was expected. True, they are also all British—but delays and overspending are just as common abroad as in Britain. In the United States, the C5-A transport aircraft is way over budget, and may cost \$900 million more than it should; the Boeing 747 is two months behind schedule, and delays on some nuclear power station contracts would make the CEGB blanch. The misfortunes of British technology are characteristic not of Britain but of technology itself. People are more conscious of the process when money is tightest, which is why in both Britain and the United States there is concern to bring it under control. The Institution of Mechanical Engineers last week organized a meeting at which project management was discussed.

Mr D. Rowley and Mr D. Metcalfe, from British Aircraft Corporation, pointed out why the original cost estimates tend to be far too optimistic. "Estimates for difficult research and development tasks are delicate things, comprising a series of judgments by many people. Often these judgments cannot be defended in argument, and only too often the pressures lead to unwisely reduced estimates." One way round this, the BAC men said, is to split the task into a mixture of cost-plus and fixed price parts. Another more provocative recommendation was that the ministries concerned should keep a semi-public league table showing how contractors' actual costs compare with estimates, and to use this as a guide in the placing of contracts. (Something of the sort is already done in the United States, and is said to have had salutary effects.) But they also criticized the Government for failing to appoint project directors, responsible for the smooth functioning of major projects; although these men exist in the Ministry of Technology, they generally have several projects under their control. As Rowley and Metcalfe pointed out: "If one cannot appoint a man of the appropriate seniority, experience and ability to run full-time on the Government's behalf a project costing, say, £100 million or more, one cannot complain if things go wrong".

The Central Electricity Generating Board, with a history of late completion which has almost become a tradition, has clearly done some heavy thinking on the subject. Mr B. C. Pyle and Mr R. N. Burbridge described the CEGB approach. One of the most important requirements is to convince designers that small changes in design late in the day are more likely to disrupt than to aid the project. "At some point in the design process, and usually when manufacture has

commenced, any change must be designated as a 'modification'; these are most disruptive." The authors also stressed the need to stimulate among all the sub-contractors a loyalty to the whole project rather than to their own sectional interests, and to encourage ruthless honesty from all concerned. Cheerful optimism about the outcome may make life easier for a while, but in the long run it is the recipe for ruin.

Motorway projects, because they involve fewer uncertainties, are more often on target. Mr W. T. F. Austin, of Freeman Fox and Partners, and Mr D. S. Elbourne, from John Laing Construction Ltd, had a good word for a form of programme presentation called "Cascade", which, they said, was better than critical path systems. The advantage of Cascade was its relative simplicity which made it possible for all involved to understand what was going on. They also made a plea for more feedback from completed projects which could prevent the same mistakes being repeated.

Many of these threads were brought together in an admirable paper by Mr H. H. Gott, managing director of Associated Nuclear Services. He made the same points about honesty in reporting of work done, and about the need to freeze the design at the right moment. Talking about power station construction, he pointed out that the man hours devoted to construction are roughly equal to the man hours expended by the operating staff during the whole life of the station, so that it is just as important to design a station to be easy to build as to be easy to operate. Another general point made by Mr Gott was the need for genuine communication between those involved in different aspects of the project, particularly by conversation. Geography and organizational restrictive practices often make this apparently simple aim hard to achieve: Mr Gott said that "one has known a number of chief draughtsmen who didn't like engineers talking to draughtsmen, and contracts officers who haunted engineering discussions like commissars requiring explanations of every point but not understanding them". Mr Gott also said that economists have tended to write textbooks about ideal situations, such as the quantity production of commodities, but nobody has yet tackled the much more difficult task of educating site managers.

EDUCATION

More Children for Science

from a Correspondent

MEMBERS of five organizations—the Institute of Physics and the Physical Society, the Royal Institute of Chemistry, the Institute of Biology, the Association for Science Education and the British Association for the Advancement of Science—met at the University of Birmingham on February 8 to discuss the shortage of science pupils in educational establishments. Opening the meeting Professor L. Rosenhead (University of Liverpool) recalled that the Dainton report has shown that although the number of students in sixth forms is increasing, the number studying science is falling at an ever increasing rate. The meeting discussed the reasons for this decline and possible ways for reversing it.

Several speakers doubted the need for more specialist scientists—there is a need of more graduates with a fundamental general knowledge but trained to think in a scientific way. Contrary to general opinion, they argued that to enter industry was not to narrow one's