FLOW MONITORS AND TELEMETRY PERFORMANCE FOR REAL TIME CONTROL

D. WALTERS *

* M. W. Barber and Company (Stockport) Limited. This paper refers to work undertaken by the author whilst he was employed by Bolton Metropolitan Borough Council.

Introduction

The question was asked in 1987 as the Bolton Town Centre Study was reaching its end, what rate of flow could be accepted into the Croal/Upper Irwell trunk sewer from the major Town Centre sub-catchment.

It was of concern to the Bolton Engineers that specifying a fixed pass forward flow from one of the many protecting storm sewage overflows (SSO's) would not effectively utilise the 20,000 m^3 storage capacity of the sewer. Furthermore it was suspected that spatial variation throughout the 12,000 ha catchment would result in spare capacity within the sewer when one sub-catchment received less rainfall than another.

To test this suspicion and to evaluated the possibility of Real Time Control (RTC). Bolton submitted a scheme to North West Water for the installation of permanent rain-gauges and flow stations within the catchment. The scheme known as FLOMAT (FLOw MAnagement by Telemetry) would accumulate data to be examined by the Water Research Centre under a 'Club' contract with North West Water. Severn Trent Water and Yorkshire Water. North West Water have also commissioned Salford University to examine the usage of Weather Radar for urban hydrology.

RTC is the method of changing the discharge conditions at an overflow, detention tank etc. so that the flow passed into the sewerage system is the optimum, thereby utilising the full capacity of the sewer without causing flooding or surcharge.

The conditions at the overflow must be adjusted in real time, to compensate for the variations in rainfall patterns, and therefore measurements of the flow must be taken and transmitted to a computer to enable decisions to be made. This technique of remote sensing and transmission is known as Telemetry.

Specification

Advice for the specification of the monitors (some times called sensors or transducers), telemetry and other electronic equipment came from a series of pamphlets issued by the Steering Group on Instrumentation, Control and Automation in the Water Industry. One of the main points of these guidelines was that the equipment should be easy to maintain and as a consequence the Contract was written so that submerged monitors were located on removable fixings.

This point is mentioned because it was the cause of the majority of the problems that arose during the project.

Contract

Lee-Dickens of Desborough, Northants won the contract to supply one flow station containing 11 depth sensors (also known as monitors) and 9 velocity sensors and 4 raingauge outstations. These flow and raingauge outstations were to be linked by telemetry to a computer master station at the headquarters of Bolton MBC Engineers.

Later the number of raingauges was increased to 10 to extend the coverage of the catchment.

The Sitewatch III system manufactured by Lee-Dickens was used for the telemetry which utilised the Public Switched Telephone System (PSTN) for the transmission of the data daily back to the Master Station. UHF radio among other alternatives were considered but discounted because of the lack of a clear line of sight for the radio waves from the valley back to the Master Station. This proved to be adequate for the data transfer requirement and despite much scepticism British Telecom's PSTN system never failed.

It must be emphasised that the PSTN would not be suitable for RTC because of the relatively slow data transfer rate and connection time.

Raingauges

Standard tipping bucket raingauges were used with one located in each sub-catchment. It was never intended to give blanket coverage, the number required for that would be impractical, but it would enable spatial variations to be identified and provide an element of ground truth for the Weather Radar study.

Flow Stations

Hydraulic models for two of the major sub-catchments, the Town Centre and the Bradshaw Valley, had previously been verified therefore the flow station was located at the confluence of the two outfall sewers, which happened to be the head of the Croal/Upper Irwell trunk sewer.

To allow for voltage drop in the 3 volt signal a local area network (LAN) with three slave outstations were configured into the flow station arrangement.

Monitors were positioned to measure depth and velocity of the flow coming into and going out of two SSO's, known locally as the Dragons Tooth and the Syphon on the Bradshaw Valley and the Town Centre sub-catchments respectively.

Most monitors were duplicated to allow for malfunction with the average of the two readings being stored for transmission.

DEPTH

The Miltronics Microranger ultrasonic depth monitor was chosen because it sat above the flow measuring the distance to the waters surface, this arrangement would eliminate the possibility of ragging or siltation affecting the readings, although there would be problems if the sewer surcharged.

Later a Scan Group 'Aquatrac' was installed into the flow at the Dragons Tooth.

Velocity

The Detectronic DET4CM ultrasonic velocity monitor was used at all locations except the metal pipebridge which carried the continuation flow from the Syphon SSO. At this location Detectronics DET72L non invasive time of flight ultrasonic monitors were used as the monitor could be fixed to the outside of the metal box section sewer and readings taken remotely.

The easy maintenance requirement led Lee-Dickens to design removable assemblies on which to mount the monitors.

Master Station

A powerful IBM compatible 386 computer was chosen for the Master Station, with sufficient memory to enable several years of data to be stored and for multi-tasking, an essential prerequisite of RTC, to be undertaken.

Running under a control program called DesQview, the purpose written software for the telemetry was run simultaneously with other MS-DOS programs such as WaSSP.

To communicate with the outstations the Master Station contained three modems all of which were on 8 bit cards held in the slots at the back of the computer.

Results

Having raingauges that gave instantaneous readings of rainfall proved a revelation. In the first 18 months of their operation no less than six storms with a profile of a once in two year storm occurred and on two occasions only months apart storms with an intensity exceeding 120 mm/hr were recorded.

With this information it became possible to compare rainfall and flooding incidence with unexpected results. For example innocuous rainfall frequently produced more flooding than the high intensity storms although the latter produced more highway flooding.

The telemetry system proved to be a success with very few problems occurring, most faults were caused by malfunctions with the computer, e.g. a clock chip failed corrupting a days data with the wrong time and date.

As expected the depth monitor sitting above the flow were the most reliable of the flow stations sensors but a problem did occur when under certain conditions, especially at low flow, the signal would resonate producing wild swings around the maximum depth value. If this happened under RTC conditions serious pollution of the water course could occur.

The contact velocity sensors (DET72L) also had limitations on depth, there had to be a minimum of 100mm of flow above the monitor to give accurate readings otherwise the readings drifted towards zero. This reduced their effectiveness since the deeper they were placed the more they became affected by siltation.

These problems were minor in comparison to those caused by the submerged monitors.

As you will recall these monitors were mounted on assemblies for easy maintenance but any lip between the mouse (monitor) and the pipe or cable carrier and pipe, resulted in ragging so quickly that cleaning was required immediately after a storm, but since this was uneconomic for a pilot scheme cleaning is only undertaken every fortnight.

Ragging and siltation were responsible for a phenomenon known as the velocity spike, which is when the difference between the two velocities from the pair of monitors increased dramatically as the flow increased at the start of a storm. This occurred irrespective of the arrangement of the monitor pair, i.e. alternate sides, on the same side or along the invert of the pipe.

By careful programming the velocity spike can be overcome but coupled with it is the gradual degradation of the signal caused by ragging. Under circumstances of constant rainfall that prevents cleaning it must be accepted that submerged monitors are going to be useless.

Conclusions

The FLOMAT scheme is an undoubted success having achieved everything expected of it.

The scheme was a test bed for the ideas of both NWW and Bolton Engineers and it provided abundant information on spatial and temporal rainfall variation, and on the equipment that would be used to control a RTC system.

Because of the scheme a better understanding of the limitations that are inherent, but previously unknown, in telemetry and remote sensing has been gained. These can now be overcome by regular maintenance, software modifications and by fail safe devices.

Furthermore the cost of a RTC system can now be assessed and compared with alternative solutions.

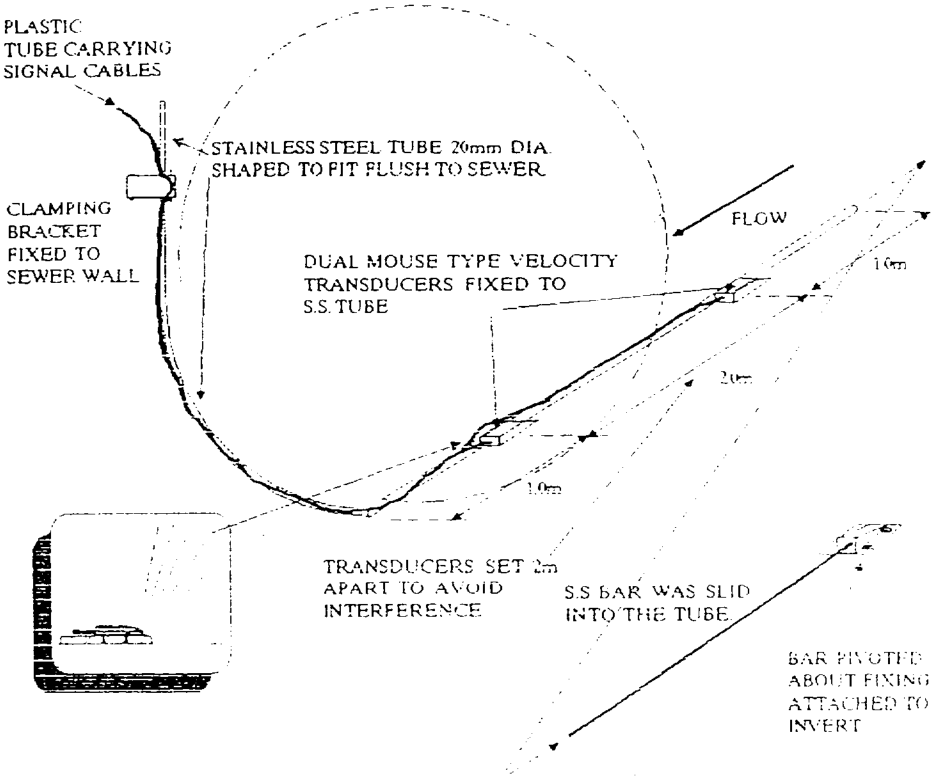
Not wishing to pre-empt the work of WRc, whose report on RTC is due out shortly, the FLOMAT scheme has shown that WaSSP is not a good model for RTC, that RTC will not cut out all pollution, and that making decisions at two minute intervals is not practical.

Whatever the findings of that report, RTC will be introduced if only for the control of pumped detention tanks.

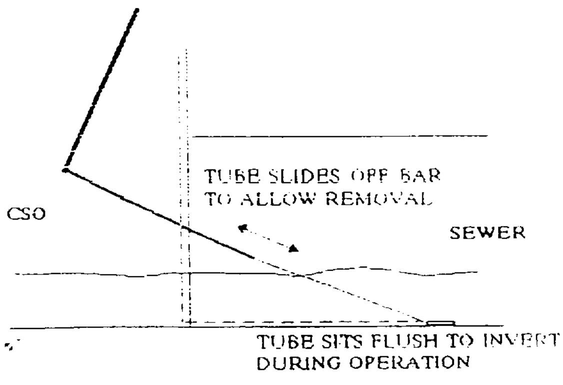
As computing power is increased and as Weather Radar is developed the capabilities of RTC will be improved, perhaps, ultimately, to the point that gravity no longer dictates to the Sewerage Engineer as he plays tunes with the system to eliminate pollution.

BarberGroup

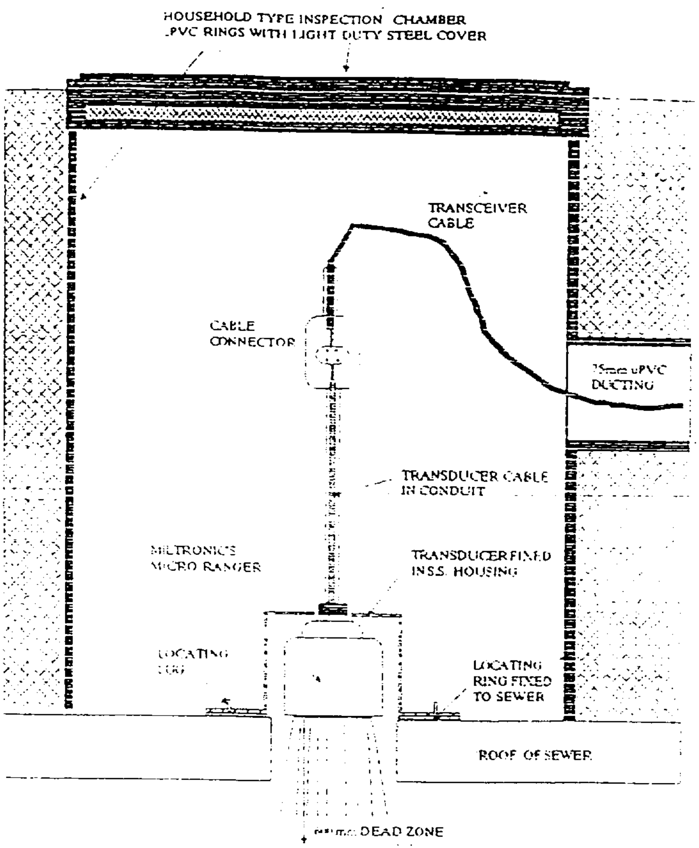
INITIAL FIXINGS FOR IMMERSED TRANSDUCERS



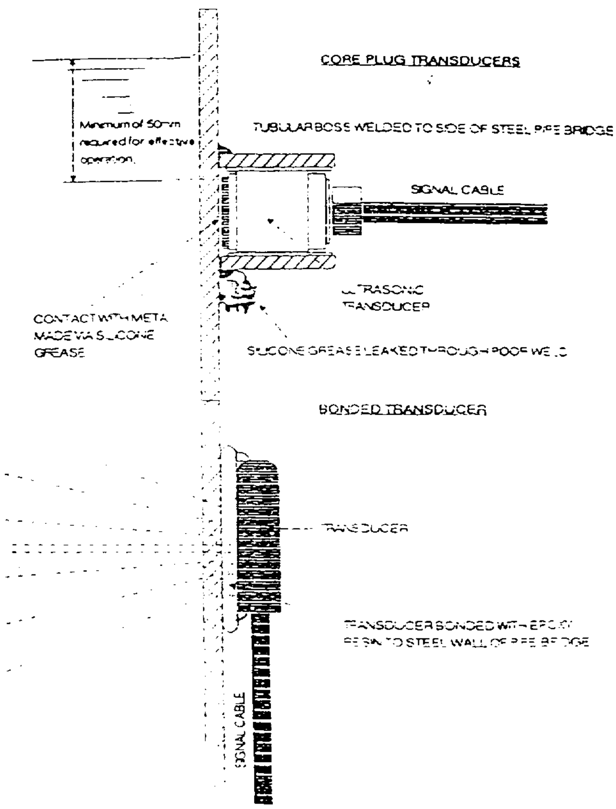
HOW THE FIXING WORKED



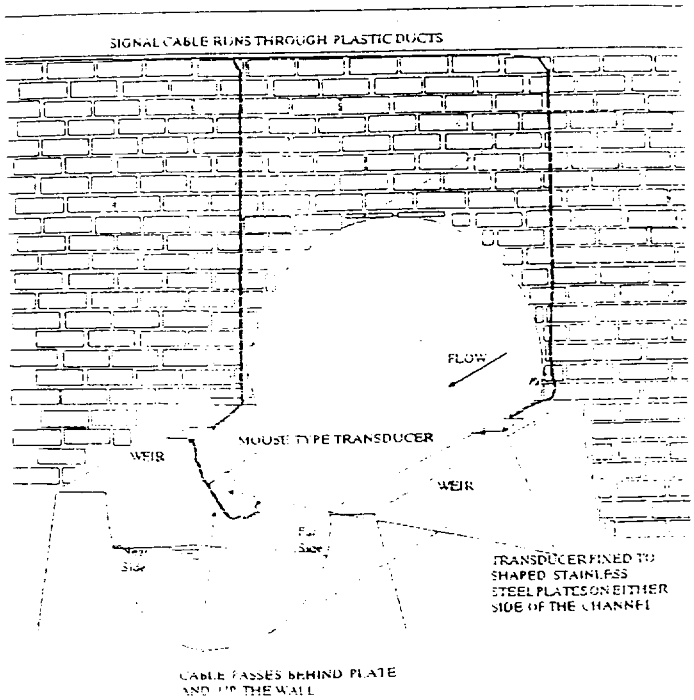
DEPTH TRANSDUCER FIXINGS



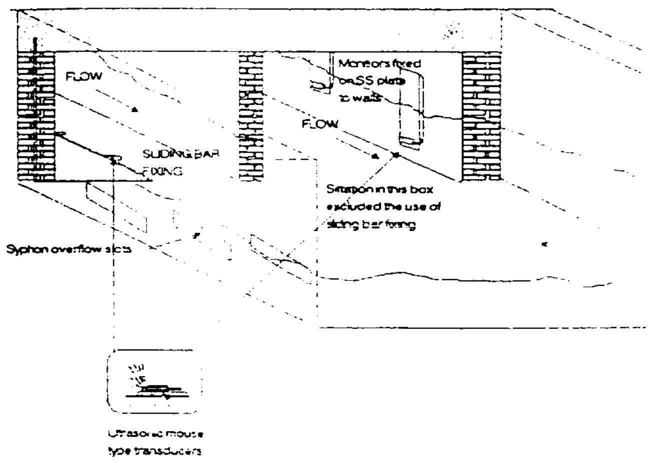
EXTERNAL TRANSDUCERS



VELOCITY TRANSDUCER ARRANGEMENT AT THE DRAGONS TOOTH C.S.O



TWIN BOX SECTION SEWERS LEADING TO SYPHON C.S.O.



Paper 4 : Flow Monitors and Telemetry for Real Time Control
(D Walters - M Barber and Co.)

Mr Jenkins (Hertsmere): What effort has to go into calibration of a Real Time Control system?

Answer: A considerable amount. Current technology depth recorders are reliable and accurate, the problem lies in determining the flow/depth relationship, especially in areas prone to backwater effects. Velocity transducers are much less accurate and prone to "drift". The aim is to build up a database or matrix of recorded rainfall events and flow conditions which the computer could interrogate to determine the RTC action to undertake.

....

D Wright (Applied Research) : RTC would appear to offer two main advantages, namely the better use of existing facilities and resulting financial savings.

Answer: Agreed, another advantage is an improvement in operational aspects.

....

G Catterson (Integrated Hydro Systems) : There are three types of RTC, i.e. passive, reactive and predictive. You seem to be concentrating on the most advanced, namely predictive. Do you not feel there is more scope for the reactive system?

Answer: Reactive is just like predictive only without the prediction (!). The system will have to react in real time whereas with predictive it will already be "set up", and can then react. I have concluded that reactive alone will not go far enough, and will create more problems than it is supposed to solve.

M Osborne (H.R. Wallingford) : As a point of information for those interested in Real Time Control, there is a seminar on this topic at Wallingford on 23 May 1991.

A Eadon (Severn Trent Water Ltd) : The problem of how much of the run off actually enters the system due to gulley restrictions has been raised again. This is particularly significant in design events. Are we moving back to a position where there is a need to reconsider the model run-off/entry conditions from scratch.

Answer: NWW Ltd interim performance criteria requires protection against flooding on a 20 year return. On the basis that Bolton was subjected to 3 storms of 1 in 20 year return in a period of 18 months and in some cases no flooding occurred, I would recommend a reassessment of performance criteria.

A Eadon (Severn Trent Water) : Gullies cause errors in modelling by limiting flow into sewers. Judy Payne is preparing a pollution model for gully pots. Is it necessary to re-examine the whole problem of gullies?

Answer: No - don't go back.