FLUIDICS

PROGRESS IN THE UNITED KINGDOM

BY

S. J. O. TINN, B.SC., C.ENG., A.M.I.MECH.E., R.N.S.S.

Only a few practical applications of fluidics have been made to date in the United Kingdom, and a significant increase in the number of systems in service is unlikely in less than two years. An outline of the extent of the United Kingdom interest is given, including a brief review of some of the applications in service or at an advanced stage of development. A full description of the various fluidic devices appeared in the last issue of the Journal, *Vol. 17, No. 1.*

Introduction

It has been said that the wide interest in fluidics reflects curiosity rather than a real desire to use the technique. While the curiosity is still widespread, a very large number of systems are being evaluated and some of these will

enter service in the next few years. There has been a rapid technological advance and applications are lagging behind slightly. This is due partly to the problem of producing integrated circuits, but more probably because fluidic control systems cannot be said to achieve any technical result which may not be obtained by existing techniques. Thus, in addition to demonstrating that they actually work, fluidic systems must show a definite advantage in the chosen application. These advantages may be briefly summarized as:

(*a*) No moving parts	This is true of the basic elements but most systems require power output devices.
(*b*) Tolerance to a wide variety of environments	The equipment can be designed to operate at extreme temperatures, it has no explosive or fire risks, and it is unaffected by radiation.
(*c*) Simplification	Some applications can take advantage of the properties peculiar to fluidic systems. This leads to enormous savings of equipment.
(*d*) Increased reliability	This can be true in harsh environments and is inherent in (*a*).
(*e*) Reduced capital costs	This is becoming increasingly true particularly where a large number of similar integrated circuit blocks are required. However, it must be remembered that compressed air must usually be provided, and compressors are often driven by electric motors to store air at 70–100 lb/sq in. for use at 2–15 lb/sq in.

As an indication of present costs, it is known that the N.E.L. fluidic measuring system for machine tools uses about 70 fluid gates. When assembled using single wall attachment elements, this presently costs about £300 allowing for manifolds and connectors. An integrated circuit is being made for £400, and production quantities of 500 to 1,000 would bring the price down to £150. Further reductions are expected in the future, and could approach the price of turbulence amplifiers (TAs) which could presently do the job for just under £100. This is not to say that TAs will necessarily provide the cheapest or best realization of a given logical requirement, as there are a variety of functions available to other systems while the TA is limited to a NOR effect. It must therefore sometimes give a less desirable system. The power gain required from the output device is also usually greater when using TAs.

The United Kingdom Effort

There is a great deal of research and system design taking place in the United Kingdom. A large part of this work is supported directly and indirectly by Government and National bodies. In addition to the work of its own establishments, the Ministry of Technology sponsors feasibility studies on a cost sharing basis with some commercial firms. It also gives grants to six Research Associations, the MTRA, PERA, PIRA, SIRA, SATRA and BHRA who in turn has contracts with some Universities, as does the SRC. The Ministry of Defence do some work in their establishments and have commissioned studies by industrial bodies; the N.R.D.C. fund some development on a commercial basis and the UKAEA, Coal, Gas and Electricity Boards have invested money in fluidic research. In the commercial world, at least 20 firms are selling components and/or designing systems for customers with many diverse interests. The

professional and technical staff employed on fluidic projects by any of the above organizations probably does not exceed 20 in any one group, and in most cases they are working in very small numbers. Many commercial design organizations have, however, expanded considerably in the past few months. It is interesting to note that the suppliers of elements have established systems groups to promote their products, while many firms designing systems have until recently found it necessary to make their own fluidic units. Several of these latter firms offer their own components for sale, or will do so in the near future.

Applications

All the applications in service in the U.K. at the present moment use turbulence amplifiers (TAs) for which the Maxam Company claim world rights. To date they have been used mainly to control various small industrial processes, but a machine tool positioning control is now being manufactured and applications are increasing in size and scope. For the rest of industry, a few systems will enter service during the next two years after which applications will increase rapidly. Many of these are at an advanced stage of development and a few examples are given under various subject headings.

Aerospace Applications

Gas turbines and rockets can provide a convenient source of working fluid. Most engine applications are likely to be part of much larger systems with the fluidic output signal converted to electrical form. Some examples are given of systems which are, or have been, rig tested, but nothing is likely to fly in under two years other than on an experimental basis.

Anti-Tank Missile Control System—BAC have tested a laboratory model which is now being engineered.

Engine Governor—A system using high pressure liquid has been fitted to an engine by Lucas Ltd. This system is entirely fluidic except for the output stage.

Inlet Guide Vane Control—A system is being engineered by the Plessey Company. Close control of vane angle is required as a function of speed and temperature.

Atomic Energy Applications

With high temperature and radiation environments, fluidics must be attractive to this industry. A number of potential applications were discussed at the second Cranfield fluidics conference, one being a fluidic multiplexing unit which could operate inside a reactor pressure vessel. This would minimize the number of expensive shell penetrations.

Computers and Data Processing

A good deal of work has been done to test fluidic systems particularly where they can replace existing mechanical ones. Several 'readers' have been developed by the Marconi Company and I.C.T. have developed a printer. All of these items could be in service in about one year, but no production decisions have yet been announced. A large scale data processing system is being studied by the Plessey Company.

Heavy Current Applications

Heavy Current Fluidics is a term which has been applied to systems where a large quantity of fluid is controlled for its own sake rather than for the analogue or digital information which it contains. The BHRA and UKAEA are interested in this field as are some commercial firms. Two applications may be mentioned.

FIG. 1—THIS PROTOTYPE SELF-CLEANING FILTER HAS A 200 G.P.M. CAPACITY

Self Cleaning Filters—This is probably the most commercially advanced of all pure fluidic applications apart from those using TAs. Serck Co. have a number of filters (FIG. 1) undergoing field trials in a variety of applications varying from filtering of river cooling water in the chemical industry to the filtration of liquid feed stock in the gas industry. The unit shown in FIG. 1 contains two mesh filters in parallel, the liquid passing through one filter until a degree of blockage causes it to switch to the second filter. A small backflow then cleans the first unit, the cycle proceeding indefinitely, the only attention required being periodic cleaning of the dirt from the settling pot. This unit could be in production in the near future.

Vortex Valve—Part of a system to control a large steam turbine for main base load electricity generation, the vortex valve is being investigated by C. A. Parsons to control steam flow directly. A fast response is necessary to achieve the degree of speed control desired. In this industry time scales are typically of the order of 5 to 10 years so that this is a long-term project.

Machine Tools

The first major applications of wall attachment devices will probably be on machine tool controls with tape or drum programming of the sequence to be followed. The N.E.L. measuring system has already been mentioned and a large number of research and commercial firms are working on positioning systems. These are intended to obtain positioning accuracies of 0·001 in. or better and operate at worktable speeds of about 200 in/min. slowing down to 0·050 in/min for final positioning. The Plessey Co. are developing an *X-Y* table which uses TAs, and Maxam themselves are currently marketing a programmed positioning system. Techne Ltd. demonstrated a drum programmed capstan lathe a year ago, and have other applications to be released soon. These last applications use the Techne spring controlled NOR element which is a borderline fluidic unit containing moving parts.

Marine Applications

Many existing pneumatic control systems could be replaced by fluidic ones but little information has been disclosed in this direction. Probable developments are boiler and steam or gas turbine controls using air or steam as the working fluid. The vortex valve would find a useful application here. Some other developments may be mentioned.

Load Warning System—One shipbuilder has fitted a Maxam fluidic detector

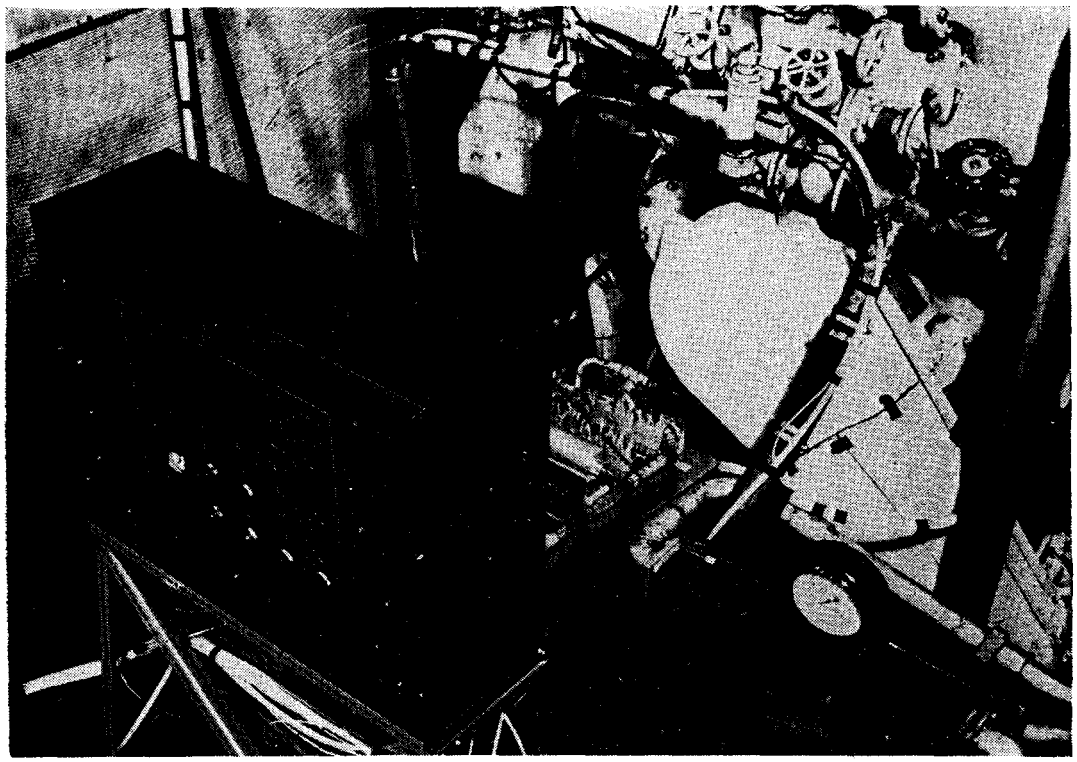

FIG. 2—FLUIDIC CONTROL BOX FOR AUTOMATIC STARTING AND WATCHKEEPING. THIS PROTOTYPE UNIT HAS BEEN RUNNING SINCE AUGUST

and alarm system in a tanker. An alarm is given when the cargo weight is approaching maximum loading.

Sequencing and Monitoring System—A sequential starting system and automatic watchkeeper has been constructed by the Plessey Co. for the MOD(N). It has been evaluated by the Admiralty Engineering Laboratory where it was fitted to a Paxman YHA 375 KVA Diesel generator set (FIG. 2). The system uses 130 wall attachment elements, mostly OR/NOR units, and the circuit requires integration before it is fitted in a ship.

Interlock System—A two-door interlock and reject system for shell handling has been fitted to a rig at ASWE. 70 TAs were used for the logic circuit, to drive 12 step-up relays.

Bridge Control of Main Engines—Another sequential system has been rig tested by Westinghouse Co. This is a fluidic version of a bridge control system for direct reversing marine engines, and it is designed to start the engine and to monitor shaft speed.

Miscellaneous Industrial Processes

This omnibus title can cover almost anything, and here the TAs have found too many applications to mention more than a few. Examples are putting stoppers in bottles, assembling filter elements, counting components, controlling liquid levels and sewing sacks. Competition is appearing from wall attachment devices. English Electric could have a wire or thread tensioner in production soon, and the mining industry may not be far behind.

Conclusions

It is hoped that the above notes have given an indication of the widespread activity in fluidic applications in the United Kingdom. Turbulence amplifiers are in service now and other systems will start to see service in 1968, building up to more widespread use about two years from now.