R.R.S. Newsletter No. 22 15th February, 1963

LASERS

Many of our staff will be aware that a programme of research involving the use of lasers is to be undertaken at the Radio Research Station. A decision to do work of this kind could have been made only quite recently, since it was in 1958 that Schawlow and Townes first suggested that oscillators and amplifiers at visible frequencies could be constructed using the 'stimulated emission' principle which had been successfully employed in masers operating in the microwave region.

Devices based on this principle make use of a substance containing atoms with two well-defined energy levels, E_1 and E_2. It is well-known that if the atom can be excited into the higher energy state (E_2, say) then radiation may be emitted spontaneously of a frequency ν such that

$$E_2 - E_1 = h\nu$$

Suppose that we pass an electromagnetic wave of frequency ν through a material containing excited atoms in state 2. It is found that this radiation can stimulate the excited atoms to emit their excess energy as radiation also of frequency ν, and having the same phase and direction of travel as the original radiation. This process of course leads to an increase of the energy in the wave as it passes through the material. Unfortunately there will often be atoms present in the lower state 1, and any atom in this state has the same chance of absorbing a photon from the original radiation as an atom in state 2 has of radiating a photon by stimulated emission. Hence it is necessary to have more atoms in state 2 than in state 1 before amplification can take place. In laser terminology this condition is often spoken of as 'population inversion' since materials will have more atoms in the lower than the upper energy state unless they are subject to some external influence.

A suitable laser material must therefore contain the two sharp energy levels already mentioned, but it must also lend itself to some scheme for giving the required population inversion. The first substance to give laser action was ruby, which is an oxide of aluminium containing a small percentage of chromium atoms. Population inversion can be attained by irradiating the ruby with intense blue or green light. This is absorbed by the ruby, and by a process of non-radiative energy loss the Cr ions in the ruby are left in an excited state which can act as state 2 in a laser. To make an oscillator out of such a system it is necessary to cut a ruby crystal in the form of a cylinder with accurately flat and parallel ends, which are then coated to make them highly reflecting at 6943 Å, the wavelength of the ruby laser emission. The blue and green 'pumping' light is concentrated on the sides of the crystal, and photons at the laser frequency build up in the cavity formed by the reflecting ends.

/A

A small proportion of these photons is allowed to escape at one end of the ruby to form the output beam.

Since the time in 1960 when ruby lasers were first made to operate, their design has been steadily improved and they have a higher power output than any others. Although continuously operating ruby lasers have been made, most of them are pulsed, with xenon flash tubes as the pump. The pulse lengths are usually around 500 μs, and power outputs exceeding 100 joules in each flash can be achieved. This corresponds to peak powers of the order of 200 kW. With special techniques the pulse length can be shortened and the peak power increased - pulse lengths of 20 ns and peak powers of many megawatts have been obtained.

Laser action has been attained in many other solid materials by similar methods. Some of the substances used are crystals and others are of glass doped with various impurities. The output frequencies are mainly in the infrared, and mostly only pulses can be emitted.

The solid state is not the only one in which laser action is possible. Gas lasers have also been developed and possess considerable advantages in certain respects over the solid-state devices. It is difficult to make solids sufficiently perfect and homogeneous, but in a gas this problem is automatically overcome by the motion of the gas molecules. Very high spectral purity of the output radiation can be obtained. Different methods of population inversion are employed in the gas laser; usually the molecules are excited in an r.f. or d.c. discharge. The first gas laser contained a mixture of helium and neon and operated at a frequency in the infra-red. With the same mixture of gases it was later found that visible radiation at 6328 Å could be obtained; continuous operation at a power level of 10 mW is possible.

No general description of this field should omit mention of the latest development - the semiconductor laser. It was found that a p-n junction in gallium arsenide would emit light when a current was passed through it. In November 1962 IBM and the American G.E. Company announced that this device had been developed into a laser by the provision of an optical cavity and by using very high current densities. Infra-red radiation at 8400 Å was first obtained, but already devices have been produced which will operate in the visible spectrum. Efficiencies of these lasers are much higher than those of any previous lasers, although their other characteristics are not as yet so good. In the U.K., S.E.R.L. have been quick to move into this field and had a gallium arsenide laser in action at the January Physical Society Exhibition.

A few words on the advantages and uses of lasers may be desirable here. The total output in light energy is not large when compared with that in a flash tube, say. However, the coherence of the laser beam is such that very high energy fluxes can be obtained, and when the beam is focussed to a point the concentration of energy is quite startling and can readily punch holes in razor blades etc. Very narrow beams and bandwidths are possible - say 1/20th of a degree and 4 Gc/s for a ruby, and much less for a gas laser. These properties make possible many uses - fine welding and surgical work, communications in space, etc.

At the Radio Research Station one of the main items on the laser research programme will probably be the study of light scattering in the upper atmosphere, which should give information about molecular (and possibly particle) densities in the 20-100 km height range. To this end we hope to purchase a ruby laser with a fairly high power output. Other kinds of research may also be undertaken, and of course a good deal of effort will be required to assemble the necessary optical test equipment. I certainly expect that those participating in the project will find that there is no shortage of interesting jobs to perform.

W. C. Bain

DATA PROCESSING AT R.R.S.

British equipment will be used for the first time to process the "raw" data received from the Anglo-American satellite to be launched by NASA next year. The satellite is at present known as S52, and is now at an advanced stage of construction. The equipment, which is being manufactured in this country, will be installed and in working order by mid-July 1963 at a special data processing centre to be set up at the DSIR's Radio Research Station, Slough. This centre will carry out the first stages in the chain of operations required before the results of each experiment can be presented in a form suitable for analysis.

In the case of ARIEL, the first Anglo-American satellite (launched on April 26th, 1962) the initial stages of data processing are undertaken by the National Aeronautics and Space Administration of the U.S.A. at the Goddard Space Flight Centre, near Washington. Later stages are carried out in this country, as they will be for S52.

In the case of S52, the magnetic tapes on which is recorded the information telemetered from the satellite will be sent to Slough from receiving stations throughout the world. They will contain intermingled measurements from several experiments recorded in a pulsed frequency modulation code together with timing information.

The new processing equipment will be required to convert this information into a digital form so that it can be used as input in fast digital computers for further processing and for eventual analysis by those taking part in the experiments.

/The

The tapes will first be "edited" to select the satisfactory parts and to assess their overall usefulness. Those tapes that are found to be of adequate quality will then be passed to the main programming and digitising part of the system where the pulsed frequency signals are separated from the background noise and recorded into a form acceptable to the digital computer.

Facilities are also provided for the experimenter to do some preliminary analysis. The processing equipment will print out data from two selected experiments and will draw graphs of up to four experiments simultaneously while it is engaged in the main task of preparing the computer's input tape.

The system is being designed in such a way that it can be modified or extended to handle other forms of telemetry if this should be required or to produce input tapes for many of the large scientific computers expected to be in service in the near future.

The processing equipment will use transistor circuits throughout and will be entirely automatic, an operator will only be necessary to load and unload the tape transports.

(Reprinted from D.S.I.R. News about Science)

OBITUARY

We regret to report the sudden death, on January 28th, of Mr. B.K. Stevens at the age of 24.

Barry Stevens joined R.R.S. in September 1959 after graduating at Sheffield University earlier that year. From that time until August 1960 his work was mainly with the newly formed Satellite group. National Service occupied him for the next two years, and he returned to the Station in August 1962. A short period of work at Winkfield was followed by his joining a group concerned with the problems of rocket and satellite instrumentation. An interest in mechanical design, allied to electronics, made him a particularly valuable worker in a field where equipment must be designed to conform with rigid spatial limitations.

To his wife and young daughter, and to his parents we extend our deepest sympathies.

STAFF NEWS

Welcome to:

Visitor

Mr. E.O. Olatunji from Ibadan University who will be with us for about a year.

New Staff

Mrs. B. Edge	T./Part-time Scientific Assistant	14.1.63
Mr. M.Z. Ullah	Labourer	17.1.63
Mr. C. Macfarlane	Instrument Maker	28.1.63
Mr. R. Barnett	Labourer	28.1.63

Resignations

Mr. J.M. Goddard	College based Sandwich Course Student	4.1.63
Mr. F.K. Williams	College based Sandwich Course Student	4.1.63
Mrs. A.I. Newman	T./Part-time Duplicator Operator II	4.1.63
Mr. M.Z. Ullah	Labourer	18.1.63
Mrs. B.K. Smith	T./Part-time Typist II	18.1.63
Dr. R.F.W. Beamish	T./Senior Scientific Officer	25.1.63

SPORTS AND SOCIAL CLUB NEWS

Smith-Rose Cup-Table Tennis

The final section of the Smith-Rose Cup is the table tennis section, and I should like to get most of the matches played by the end of March. Will people interested in taking part please see me or sign the list on the notice board.

M. Williams

Bridge

The R.R.S. bridge team had a win by the narrow margin of three International Match Points in a match with a team from N.P.L. on January 25th.

The pairs representing R.R.S. were:

W.C. Bain and J. Scott
V. Owen and B.L. Garner
J. Harwood and E.N. Bramley
A.C. and K. Gordon-Smith

A.C. Gordon-Smith

/Visit

Visit to "Beyond the Fringe"

On Saturday, February 9th, a group of about 30 R.R.S. Sports and Social Club members left Datchet by coach for London to see a performance of "Beyond the Fringe", a satirical revue at the Fortune Theatre, Drury Lane. It can be said that the style and irreverence of the revue was not to the taste of every member of the party, but the majority enjoyed it. It is obvious that a show of this nature must offend some people as indeed is intended; satire is not everybody's cup of tea as it is usually served without sugar!! Our thanks go to Margaret Horwill who ably organised the visit.

Weather Note

At 0900 hrs on 23rd January the outside temperature at Ditton Park was found to be -15°C. Nobody knows if this is a record; but everybody agrees that no attempt to surpass it is wanted.

December shed its wintry light;
Snow and frost came with the night;
Icicles soon brightly glittered;
Rivers froze, birds hardly twittered.

Rising currents warmed the air,
Reaching earthwards, showing where
Spring is thrusting her green spear.

LETTER TO THE OUTSTATIONS

Dear Colleagues,

The past few weeks have seen the return of several members of the staff from visits abroad. The Deputy Director and Mr. Horner are back from the C.C.I.R. meeting at Geneva, and Dr. King has completed his visit to Canada and the U.S.A., where discussions about the top-side sounder have been held. Mr. Lane, who spent the last five months in the States, mainly at C.R.P.L., Boulder, has now returned to face the pleasures of an English February. During this spell of duty he was able to renew acquaintance with Dr. Rishbeth and Dr. and Mrs. Hargreaves, all one time staff of R.R.S. Another former member of the staff, David Cowlishaw, has recently been seen. He has, it appears, decided to exchange a policeman's lot in Hong Kong for that of a businessman in Great Britain.

Compiling a newsletter, and for that matter an outstations letter as well, becomes easier in proportion to the amount of information available. It is partly our job to seek out contributions from the staff; but we are always pleased to hear from anyone either at home or overseas, who may have the itch to write. Letters to the Editor do not appear as a regular feature only because they are not forthcoming. Please remember that all contributions will, as they say, be gratefully received by your colleagues, and not least by,

Yours sincerely,

The Editor