of normal operations of a nuclear ship may be dis-
charged into the open sea without undue risk to man.
Harbours, estuaries and other inshore areas appear
unsuitable for the discharge of wastes of intermediate
activity, but many harbours could receive the low
level liquid effluent without any unacceptable hazard.
The continental shelf and coastal area can safely re-
ceive the low level liquid wastes but cannot be recom-
mended as suitable for the release of wastes of in-
termediate activity.

The Panel has recommended that the disposals
from a nuclear ship should be entered in a record
maintained on the ship and available for inspection by
port authorities. An abstract of the record could be
transmitted to the Intergovernmental Maritime Con-
sultative Organization which, jointly with IAEA,
should work out an effective registration and compi-
lation of disposals from nuclear ships.

All disposals from ships in harbours and na-
tional waters should be in conformity with conditions
laid down by the local authority. Disposals in inter-
national waters should conform to conditions speci-
fied in the licensing of the vessel or by the appro-
riate international authority.

Finally, the Panel has recommended that IAEA,
in collaboration with other international organizations
concerned, should review all these problems at ap-
propriate intervals.

FABRICATION OF FUEL ELEMENTS

The prospects of economic nuclear power depend
to a large extent on the lowering of fuel costs by
achieving the maximum yield of acceptable fuel el-
ements during the fabrication process and by a more
effective utilization of the fuel in the reactor system.
In fact, the efficiency of a reactor during operation
is in a significant measure a function of fuel technology
and is dependent upon the form and arrangement in
which the fuel elements are placed in the reactor
system.

The primary consideration, of course, is a self-
sustaining, controlled fission chain reaction, and the
fabricated elements must contain right amounts of fuel
and placed in a geometry within the reactor that would
facilitate such a reaction. Usually these elements are
in the form of rods, plates or other structures of fis-
sile material "clad" or closely sheathed in metal con-
tainers. The metal cladding or can protects the fuel
element from damage by other substances in the re-
actor system: it prevents the fuel from coming in
contact with water or other moderator materials with
which it reacts vigorously whenever a fuel element
failure occurs. Such a failure in most cases requires
the reactor to be shut down to remove the defective
fuel element. The canning also serves to contain the
fission products and facilitates the handling of irra-
diated fuel during chemical reprocessing.

These requirements demand complex techniques
of fabrication and cladding, and considerable research
has been going on in a number of countries with the
object of improving these techniques. Many of them
were discussed in detail at an international symposium
held by IAEA in Vienna last May. The symposium,
which was in session from 10 May to 13 May 1960, was
attended by nearly 200 experts from 23 countries.
Representatives of the OEEC and the Euratom also
took part in the meeting.

In his opening speech at the symposium, the IAEA
Director General, Mr. Sterling Cole, stressed the
importance and complexity of development of fuel el-
ement fabrication techniques and especially the role
of cladding materials in lowering fuel costs. He ex-
plained that for the efficient and economic operation
of a power reactor the fabricated and clad fuel el-
ements must be able to stand up to high temperatures
and also contain the fission products within them-

selfs. Furthermore, the capture of neutrons by the
cladding materials must be sufficiently low not to
affect the conversion of fertile into fissile material.
(By neutron irradiation, fertile material, such as
uranium 238 or thorium, is converted into plutonium
or uranium 233 which are fissile materials.)

Cladding Materials

The special emphasis at the symposium was on
cladding materials and the first two sessions were
devoted to a discussion of the characteristics of mate-
rials that can be used for canning. A number of
papers were presented and discussed on different
aspects of the principal cladding materials, such as
aluminium, zirconium, zirconium alloys and graph-
ite. The views expressed were supported by practical
experience, and several suggestions were made for
improvements in the use of these materials.

At the next two sessions, some of the technical
problems of fuel fabrication were taken up, and the
papers presented contained accounts of fuel fabrication
facilities and methods employed in several countries.
This was followed by a session on quality control and
inspection; the topics discussed included tightness
control, production control and the applications of
microradiography for inspection. Problems raised
by corrosion and radiation damage of cladding mate-
rials were considered at the following session, and
the discussions covered not only the radiation effects on cladding materials in general but also the effects of irradiation and oxidation on specific canning substances.

The last two sessions of the symposium were devoted to discussions on the economics and general trends of development of fuel element fabrication, on which several papers were presented. The subjects considered included the relationship between a reduction in fabrication costs and the price of nuclear power, economic consequences of variations in fuel element designs as well as some problems connected with particular reactor types. Attention was also drawn to the significant trends in current research in some of the advanced countries, and the likely developments were appraised in broad terms.

The following scientists, all of whom are eminent specialists in the field, served as discussion leaders: Mr. Alfred Boettcher (Germany), Mr. Spencer H. Bush (USA), Mr. Jacques Huri (France), Mr. Alexander B. MacIntosh (UK) and Mr. Shuichiro Takahashi (Japan).

The proceedings of the symposium will be published later this year.