The output from the amplifier **30**$b'$, consisting of trains of 48 pulses each of energy about 150 mJ per pulse, is focussed by the lens **19** on to the X-ray target (tape **16**), forming four or eight focussed spots **42**, each corresponding to one of the angularly separated pulse trains produced by the multiplexer **40** and also, possibly, **29**. The distribution of the spots **42** can be controlled by choice of the geometry of the multiplexers **40** and **29**.

If the large-area output amplifier **30**$b'$ gives an average power of 1 KW when operated at 100 Hz with stable laser cavity and 80 ns pulses of 10 J per pulse, then an average power of 720 watt may be obtained when the amplifier is operated as described above, with trains of 48 5 ps pulses and a train repetition rate of 100 Hz; and this will result in an average X-ray power, within the spectral range 0.9–1.2 nm, of 36 watts at 5% X-ray conversion efficiency.

It will be understood that the train of sixteen pulses issuing from the multiplexer **29** shown in FIG. **4**, in response to a single input pulse on the mirror **29**$a$, consists of two successive sub-trains each of eight pulses, of which the second sub-train has been delayed by the delay line **29**$g$ relative to the whole of the first sub-train, and that the overall duration of the train will be 32 ns if the pulse separation is 2 ns. Thus if the discharge time of the amplifier **30**$a$ to which the pulse train is applied is about 22 ns, the amplified output pulse train will contain about twelve pulses at most. If the discharge times of the output amplifier **30**$b$ are also about 22 ns, any jitter in the firing of these amplifiers will result in less than all the pulses being amplified and in a reduction of the energy extracted from the amplifier. In the modified arrangement shown in FIG. **10**, a multiplexer **29'** produces two simultaneous pulse sub-trains, each of eight pulses, which are then propagated simultaneously in opposite directions through the driver amplifier **30**$a$ prior to being combined into a single train of sixteen pulses of which the second sub-train of eight pulses is delayed relative to the first sub-train and is arranged to be propagated at a small angle (of about 1 mrad) relative to the first sub-train. It will be appreciated that in this arrangement, there is ample time for all eight pulses of each sub-train to be fully amplified during discharge of the driver amplifier **30**$a$, and that all sixteen pulses are preserved, amplified, in the recombined pulse train.

In the arrangement shown in FIG. **5**, the lenses provided before and after the amplifier **30**$a$ have a telescopic effect corresponding to that of the telescope **41** in FIG. **9**, and a corresponding telescopic effect may be associated with the amplifier **30**$a$ in FIG. **10** by providing lenses **42** and **43** before and after this amplifier to provide a first beam expansion from about 1 mm to 4 mm diameter through the amplifier **30**$a$. Preferably, also, a further expansion of the recombined full pulse train emitted from the amplifier **30**$a$ is provided by passing it through a telescope **41'**, combining lenses **41**$a'$ and **41**$b'$, for spatial mixing of the two sub-trains and for expanding the beams for matching the apertures of output amplifiers **30**$b$ to which the pulse train is then applied via a beam splitter arrangement **30**$c'$ which divides the pulse energy equally between those amplifiers. The combined expansion provided by the lenses before and after the driver amplifier **30**$a$ and by the telescope **41'** may be equal to that produced by the lenses before and after the driver amplifier **30**$a$ in FIG. **5**, if the output amplifiers in FIGS. **5** and **10** have comparable apertures, which may for example be 1.3×2.5 $cm^2$.

As explained above, the pulse train applied to the beam splitter **30**$c'$ contains a full sixteen pulses and has a train duration of approximately 32 ns, and this is sufficient to accommodate any jitter in the firing of the output amplifiers **30**$b$, and to ensure full energy extraction over the whole duration of the amplifier discharge.



The pulses applied to the driver amplifier **30**$a$, as two simultaneous but oppositely directed sub-trains each of eight pulses, may be 1 μJ pulses each of 5 ps duration and with a sub-train duration of 12–15 ns. The pulses are amplified to about 4 mJ each by the amplifier **30**$a$, and one sub-train is delayed relative to the other by a time equal to eight times the pulse repetition time before recombination to provide a single pulse train of sixteen pulses, with a pulse train duration of 24–30 ns. The beam splitter **30**$c'$ divides the energy of each pulse equally between the output amplifiers **30**$b$; If there are four of these, each will receive a train of sixteen 5 ps pulses, each of energy about 1 mJ with a pulse train duration of 24–30 ns which is comfortably longer than the discharge time of the amplifiers **30**$b$, which is about 20 ns. The firing of the amplifiers **30**$b$ under control of the control unit **12** can therefore be synchronized so that, even allowing for jitter, pulses of the train are applied throughout the amplifier discharge time so as to achieve maximum energy extraction from each amplifier **30**$b$.

The output of each amplifier **30**$b$ will be a train of about 20 ns duration, containing about 12 (perhaps 11 or 13) pulses. If each of the amplifiers **30**$b$ is a "200 watt output amplifier", i.e. one which can deliver 200 watt when arranged conventionally with plane mirrors and a stable cavity, and pulsed with 22 ns pulses at 200 Hz, it will be capable of delivering 140 watt average power when operated as described above, with nanosecond pulses at 200 Hz replaced by trains of picosecond pulses and a pulse-train repetition rate of 200 Hz. Thus four such amplifiers **30**$b$ in parallel can deliver a total of about 560 watt average power for focussing on the target tape in a single spot or, by angular beam separation as described with reference to FIG. **9**, in a cluster of spots **42**. At an X-ray conversion efficiency of 5%, this will yield 28 watts X-ray average power in a spectral range of 0.9–1.2 nm.

We claim:

**1**. An X-ray source comprising:

a target;

a laser light source; and

means for focusing light from the light source on to the target, thereby to heat a region of the target and generate therefrom a plasma adjacent thereto which emits X-ray;

wherein the laser light source generates trains of light pulses each having a pulse duration in a range 1–10 picoseconds.

**2**. An X-ray source as claimed in claim **1**, wherein:

the laser light source generates trains of pulses of ultra-violet light.

**3**. An X-ray source as claimed in claim **1** or claim **2**, wherein:

the laser light source has an output power such that light therefrom focussed on the target will illuminate the region of the target with an irradiance to generate X-rays at a wavelength no greater than one nanometer.

**4**. An X-ray source as claimed in claim **1**, wherein:

the laser light source generates trains of pulses with a pulse repetition time in a range 1.5–2.5 nanoseconds.

**5**. An X-ray source as claimed in claim **1**, wherein:

the laser light source generates pulse trains with a pulse train repetition rate in a range 100–10000 Hz.

**6**. An X-ray source as claimed in claim **1**, wherein the target comprises: